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EVALUATION OF COMPOSITE WING FOR XFV-12A AIRPLANE. APPENDIX C.(U)
OCT 78 N62269-74-C-0577

UNCLASSIFIED NADC-77183-30-APP-C NL

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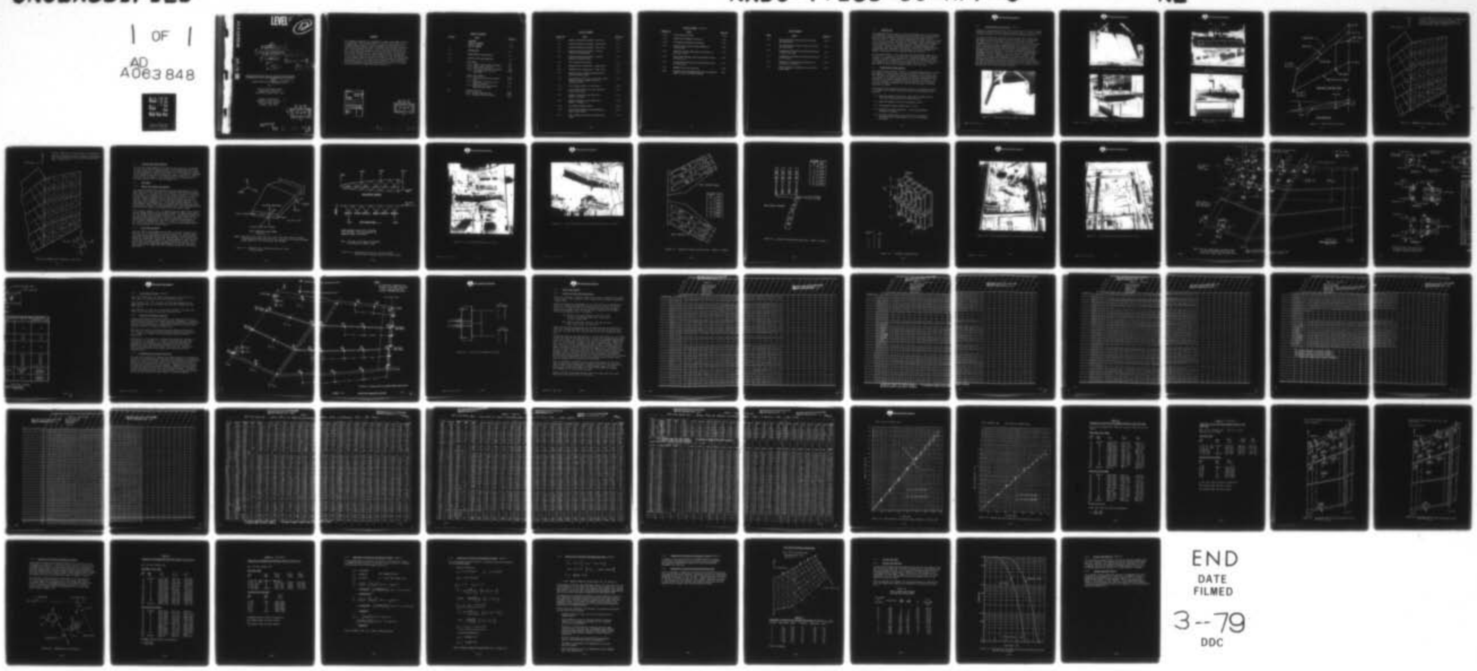

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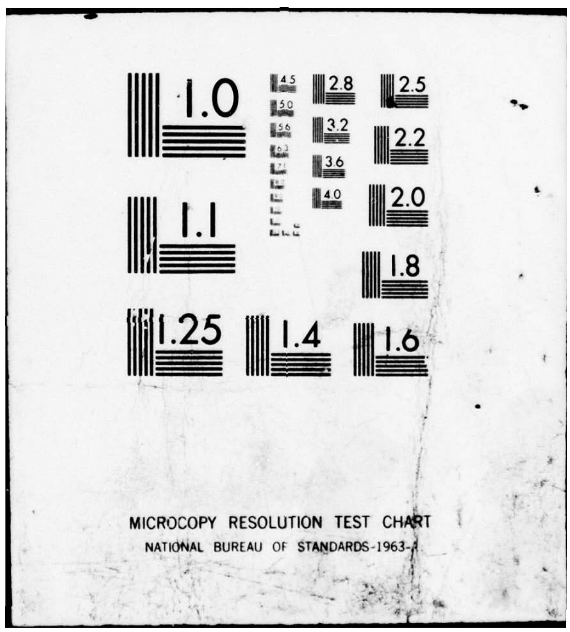
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12

APPENDIX C

NADC 77183-30-APP-C

EVALUATION OF COMPOSITE WING
FOR XFV-12A AIRPLANE. Appendix C.

13 OCTOBER 1978

Final rept.

Aug-Sep 78

69p.

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

Prepared Under Contract N62269-74-C-0577

For

Naval Air Development Center
Department of the Navy
Warminster, Pennsylvania 18974

Rockwell International
Columbus Aircraft Division
4300 East Fifth Avenue
Columbus, Ohio 43216

404390

FOREWORD

This Appendix, prepared as a supplement to final report NADC-77183-30 dated December 1976, presents results of static and fatigue tests of a graphite/epoxy wing box structure designed and fabricated by the Columbus Aircraft Division (CAD) of Rockwell International Corporation under contract N62269-74-C-0577. These tests were conducted by the Navy at the Naval Air Development Center, Warminster, PA. during the period August-September 1978. Static loads to 150% of design limit load for the critical carrier based landing condition were applied to the composite wing box structure followed by a two lifetime fatigue spectrum loading with no evidence of structural damage or deformation. Descriptions of the test setup, applied loadings, strain gage data, deflection transducer data, and comparisons of predicted vs recorded strain and deflection measurements are presented.

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C-1 INTRODUCTION

This Appendix presents results of static and fatigue tests of a graphite/epoxy wing box structure designed and fabricated by the Columbus Aircraft Division (CAD) of Rockwell International Corporation under contract N62269-74-C-0577. These tests were conducted by the Navy in the structural test facility located at the Naval Air Development Center, Warminster, PA. Static loadings to 150% of design limit load were completed on 9 August 1978 with no evidence of structural damage or permanent deformation. These static load tests were followed by a two-lifetime fatigue spectrum loading which was completed on 20 September 1978 with no evidence of damage or deformation of the composite wing box structure.

Setup and performance of test operations were accomplished under the direction of J. J. Minecci, test director, and Ralph Vining, test engineer of NADC. The NADC project engineer for the XFV-12A composite wing box evaluation was M. S. Rosenfeld. All or portions of this series of tests were witnessed by the above listed personnel and by Dr. S. L. Huang of NADC and D. N. Ulry of the Columbus Aircraft Division (CAD).

C-2 DESCRIPTION OF TEST ARTICLE

The composite wing structure consists of a graphite/epoxy wing box section approximately 88 inches long, 80 inches wide and 12 inches thick. The test specimen, illustrated in Figures C-1 through C-5, is representative of a section of the XFV-12A main wing box structure extending from the centerline of airplane outboard beyond the mid-span of the wing. The test box structure is representative of all aspects of an actual wing structure including provisions for internal fuel and wing to fuselage attachment fittings.

Construction of the composite wing box structure is described in detail in the NADC-77183-30 final report and contains the following salient features:

(1) Honeycomb sandwich cover skins consisting of graphite/epoxy face sheets and glass/phenolic honeycomb core.

(2) Honeycomb sandwich front and intermediate spars.

(3) Solid graphite/epoxy laminate B.P. 33 rib.

(4) Aluminum rear spar, centerline rib and wing/fuselage attachment fittings.

(5) Adhesively bonded lower cover skin to spar attachment and mechanically fastened upper cover to sub structure attachment.

C-2 DESCRIPTION OF TEST ARTICLE (Cont'd.)

Structural test provisions built into the wing box test section include bolting attachments integral with the aluminum center line rib as shown in Figure C-4 and steel tip loading plates as shown in Figure C-5.

The actual XFV-12A wing is bolted to the fuselage with a three point attachment as shown in Figure C-6 with one front spar attachment at the centerline of the airplane, one L.H. and one R.H. rear spar attachment at B.P. 33.93. For the purpose of this test a L.H. portion of the wing box was rigidly supported along the centerline rib and loads, as determined from a NASTRAN analysis representing the test box specimen and structural test restraints, were applied at the outboard end of the specimen. Statically determinate wing/fuselage attachment loads were applied at the B.P. 33.93 aft wing/fuselage attachment fitting. Figures C-7 and C-8 present a summary of the differences in stress distributions in the upper and lower cover skins as determined from the NASTRAN analysis of the actual wing attachment provisions versus the test article restraint conditions. The small percentage of difference determined in this analysis verifies the rationale and economy of constructing only a L.H. portion of the wing box for full scale structural testing.

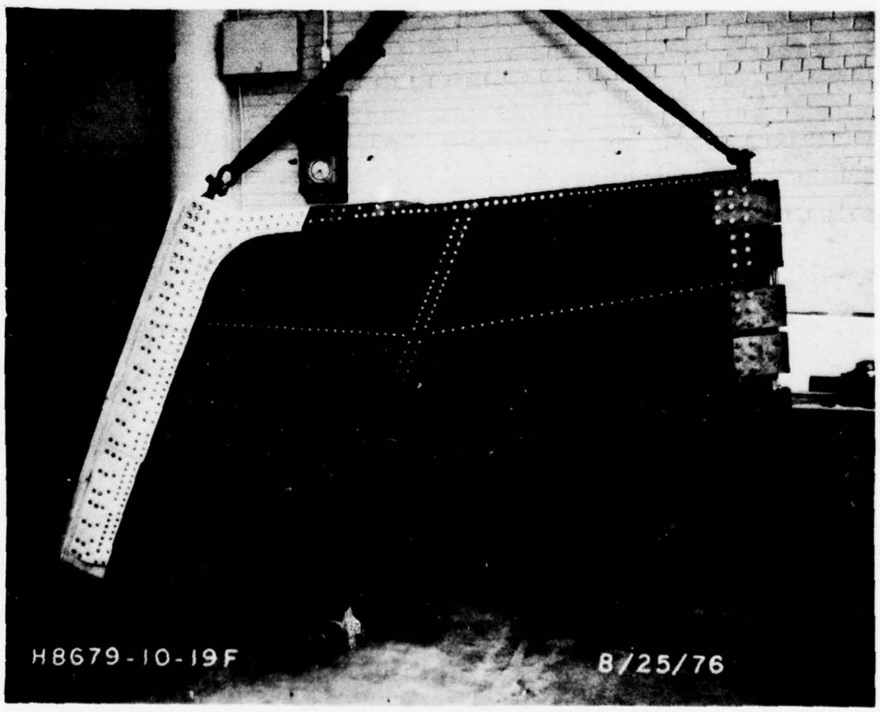

Figure C-1 Composite Wing Box Assembly - Top View

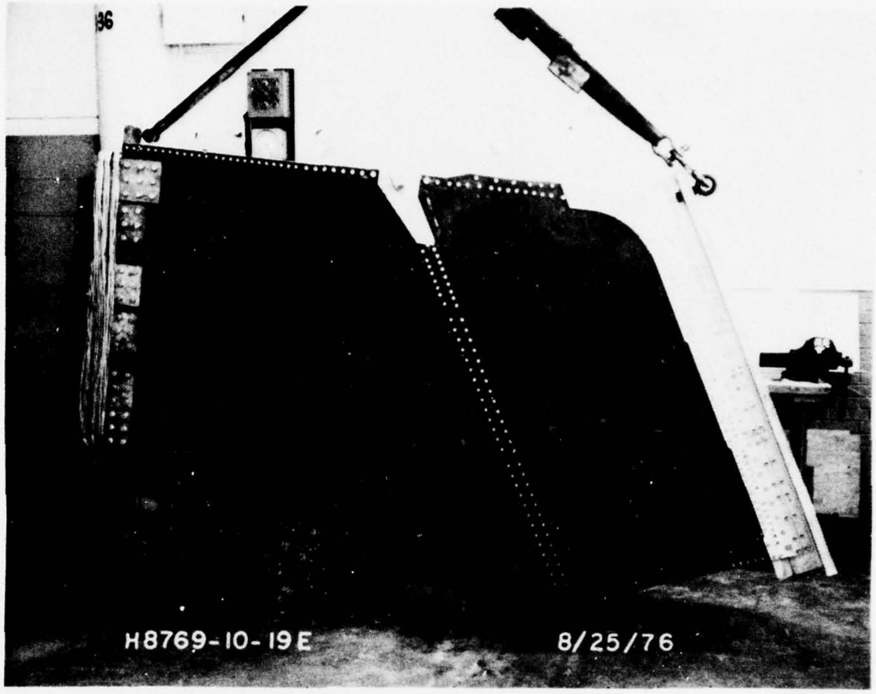

Figure C-2 Composite Wing Box Assembly - Bottom View

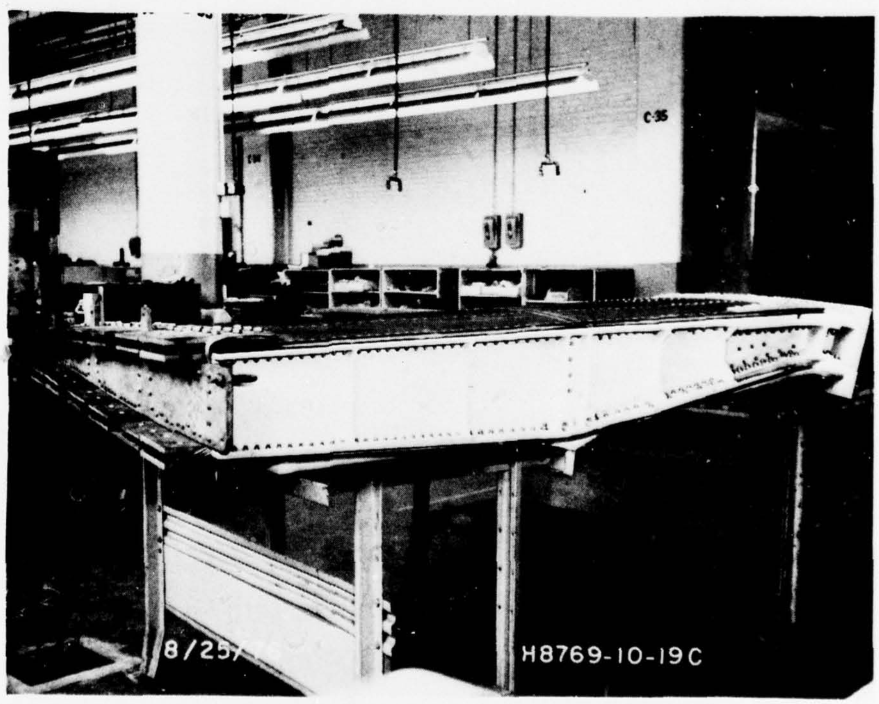

Figure C-3 Composite Wing Box Assembly - Rear View

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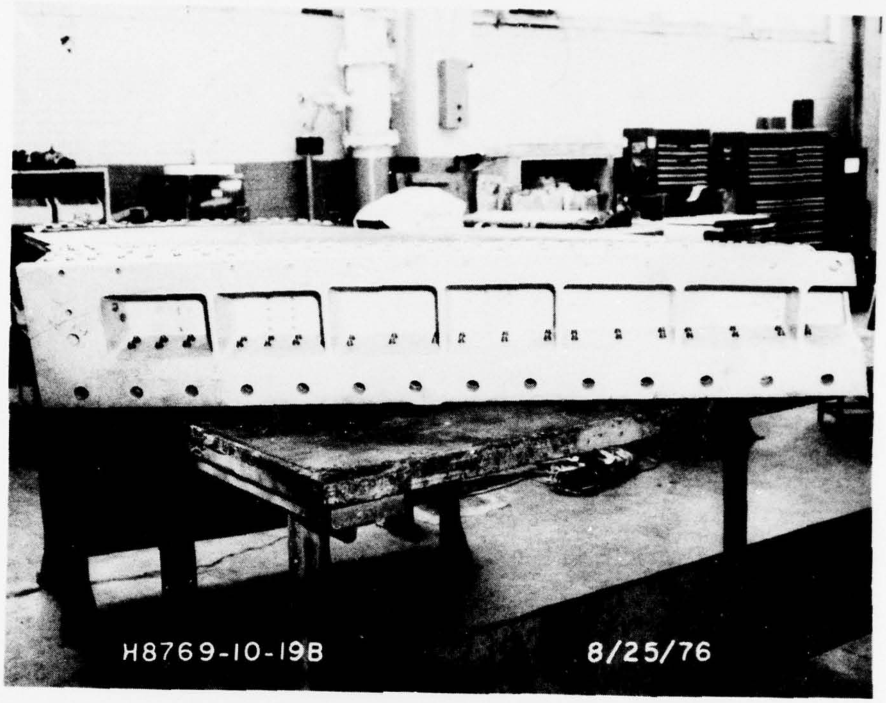


Figure C-4 Composite Wing Box Assembly - View of Centerline Loading Rib

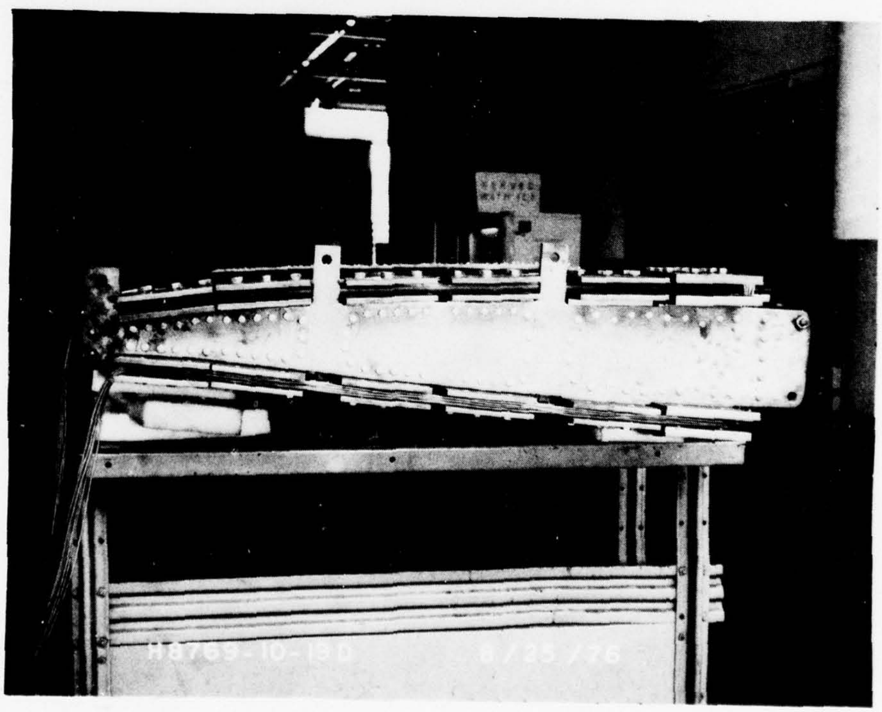


Figure C-5 Composite Wing Box Assembly - View of Outboard Loading Fixture

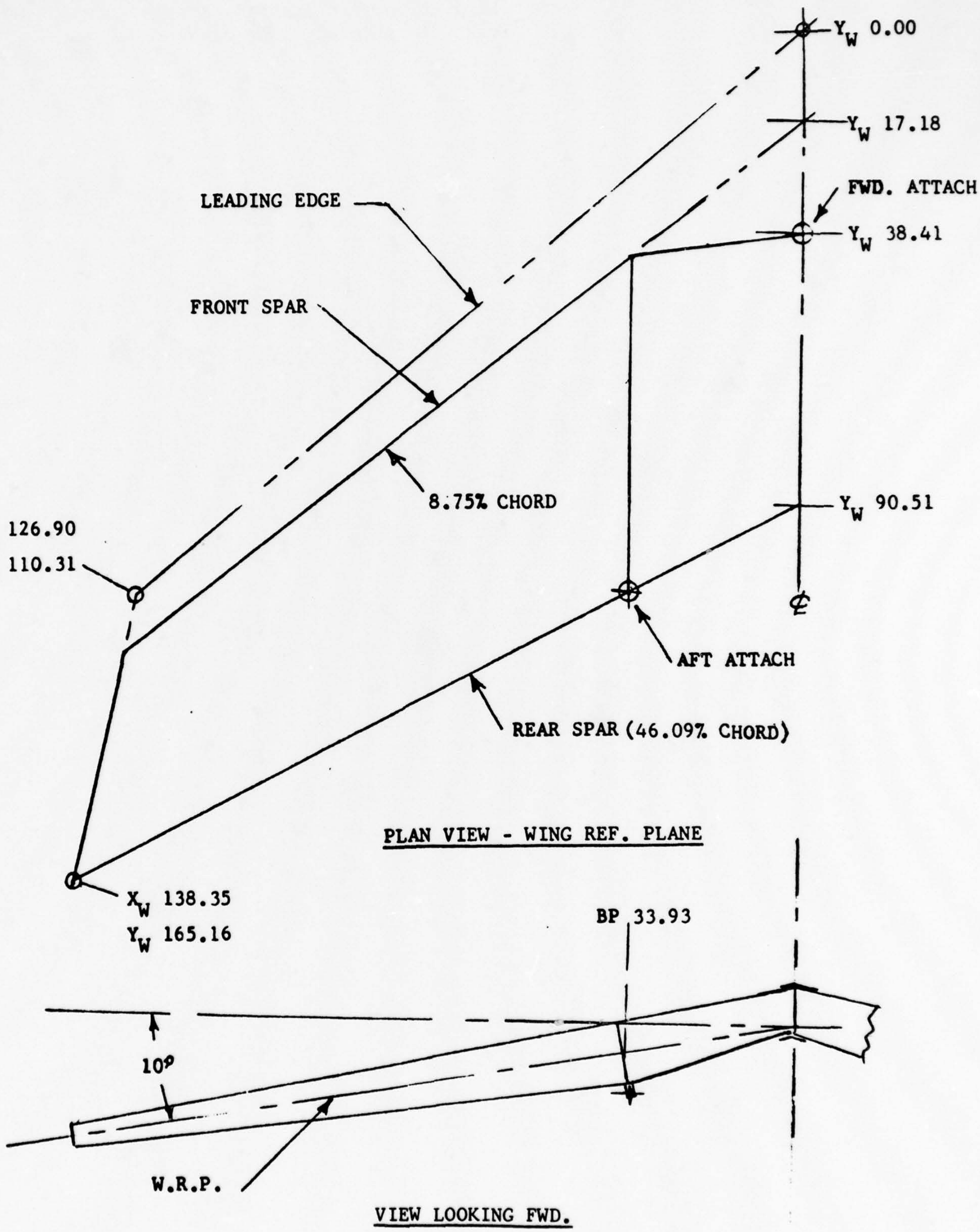


Figure C-6 XFV-12A Wing Box Geometry

% Error of σ_x for test article support configuration relative to airplane installation support configuration (max. vertical landing condition and max. operational loads 150% D.L.L.)

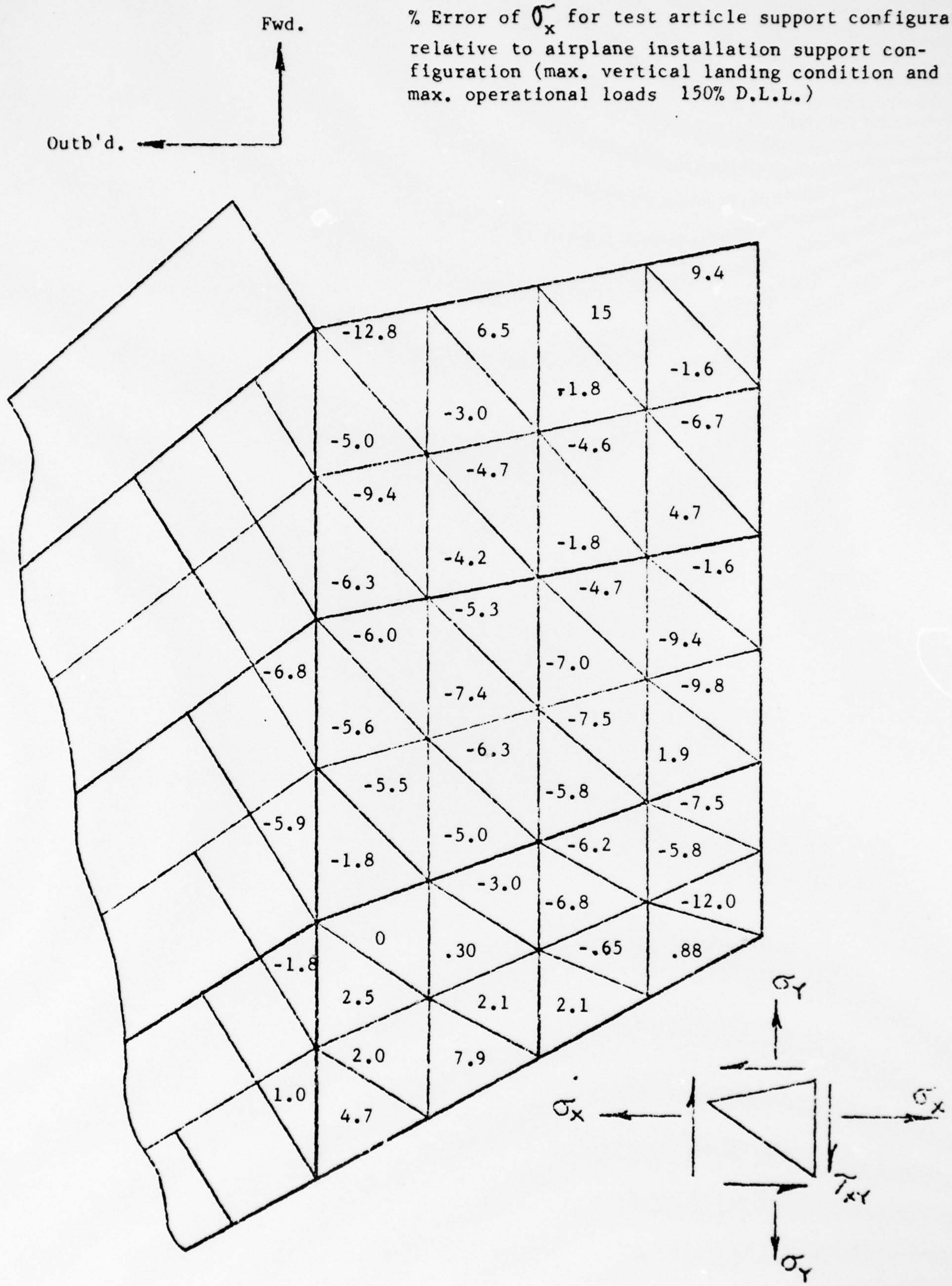


Figure C-7 NASTRAN Stress Comparison - Upper Cover

% Error of σ_x for test article support configuration relative to airplane installation support configuration (max. vertical landing condition and max operational loads 150% D.L.L.)

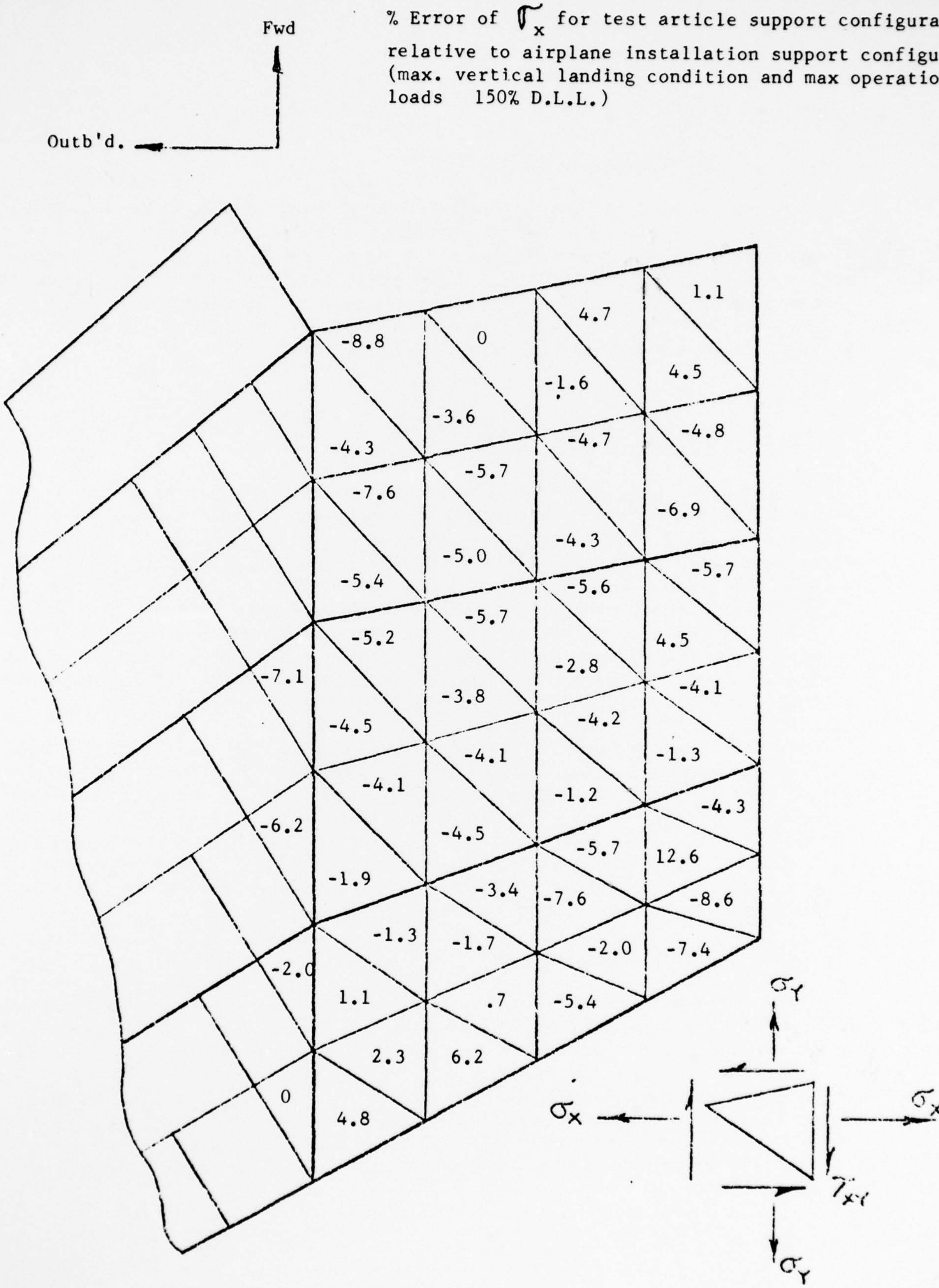


Figure C-8 NASTRAN Stress Comparison - Lower Cover

C-3 CRITICAL TEST LOAD CONDITION

The critical design loading for the XFV-12A wing structure is a maximum vertical carrier based landing condition. The maximum operational loads for this condition are considered "ultimate" for design and test purposes and are equivalent to 150% of design limit load. Test loads to be applied to the composite wing box test section are shown in Figure C-9. Distribution of the test loads at the outboard end of the test specimen at rear spar Station 79.54 is shown in Figure C-10.

C-4 TEST SETUP

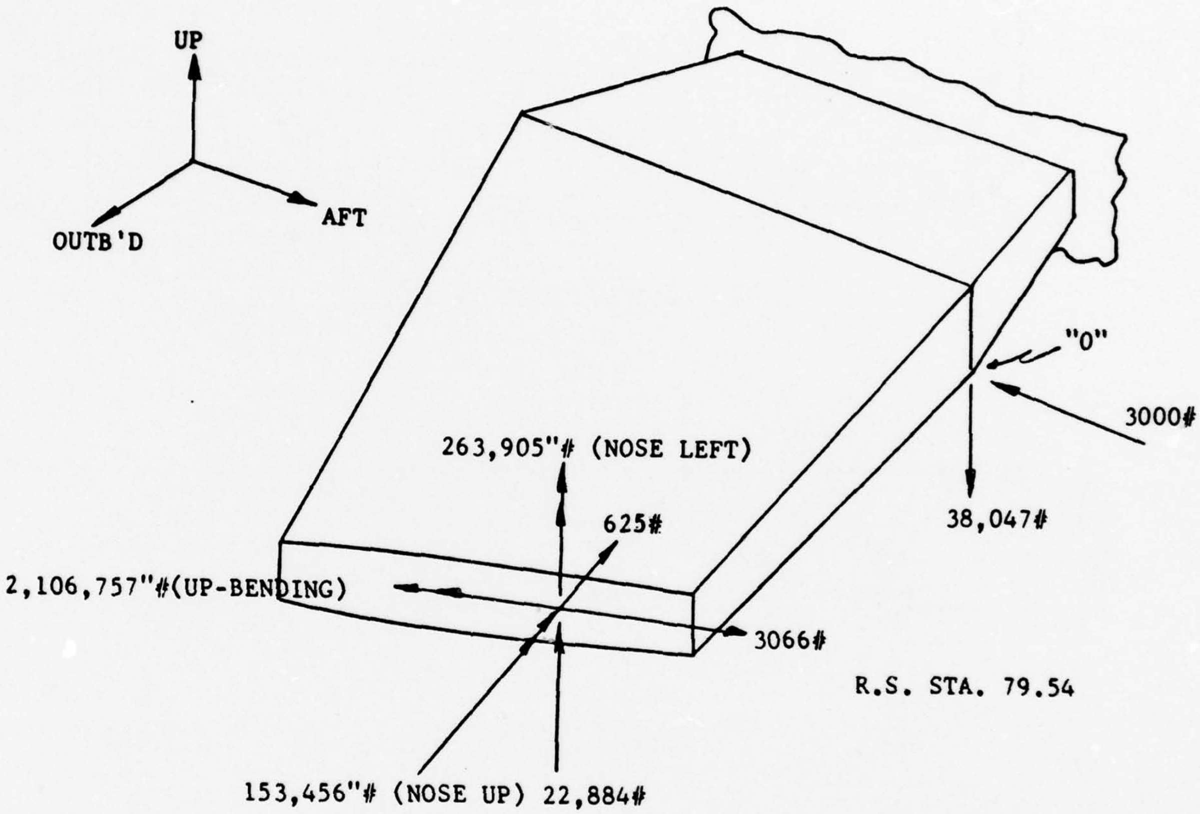
C-4-1 Support and Loading Arrangement

The composite wing box test specimen was mounted approximately ten feet above the floor of the structural test laboratory with the wing reference plane parallel to the plane of the floor as shown in Figure C-11 and C-12. In this setup the centerline root rib was securely bolted to a series of vertical I-beams to provide the basic cantilever support for the test specimen. Twelve hydraulic actuator jacks were used to apply the test loads specified in paragraph C-3. Six actuators mounted parallel to the wing reference plane (three above the specimen and three below the specimen as shown in Figure C-13) applied moment load to the tip loading fixture. Load from these actuators was reacted at the root support beams.

Four actuators (number 7, 8, 9, 10) applied vertical shear load & torque to the tip loading fixture and one actuator (number 11) applied drag load to the tip loading fixture as shown in Figure C-14. One actuator (number 12) was used to apply the specified vertical and drag load at the B.P. 33.93 wing/fuselage attachment fitting. Figure C-15 presents dimensions of the tip moment loading beams. Figures C-16 and C-17 show forward and aft views of the overall test setup. All actuators and loading fixtures were counterbalanced for 1G dead weight.

C-4-2 Strain Gage Locations

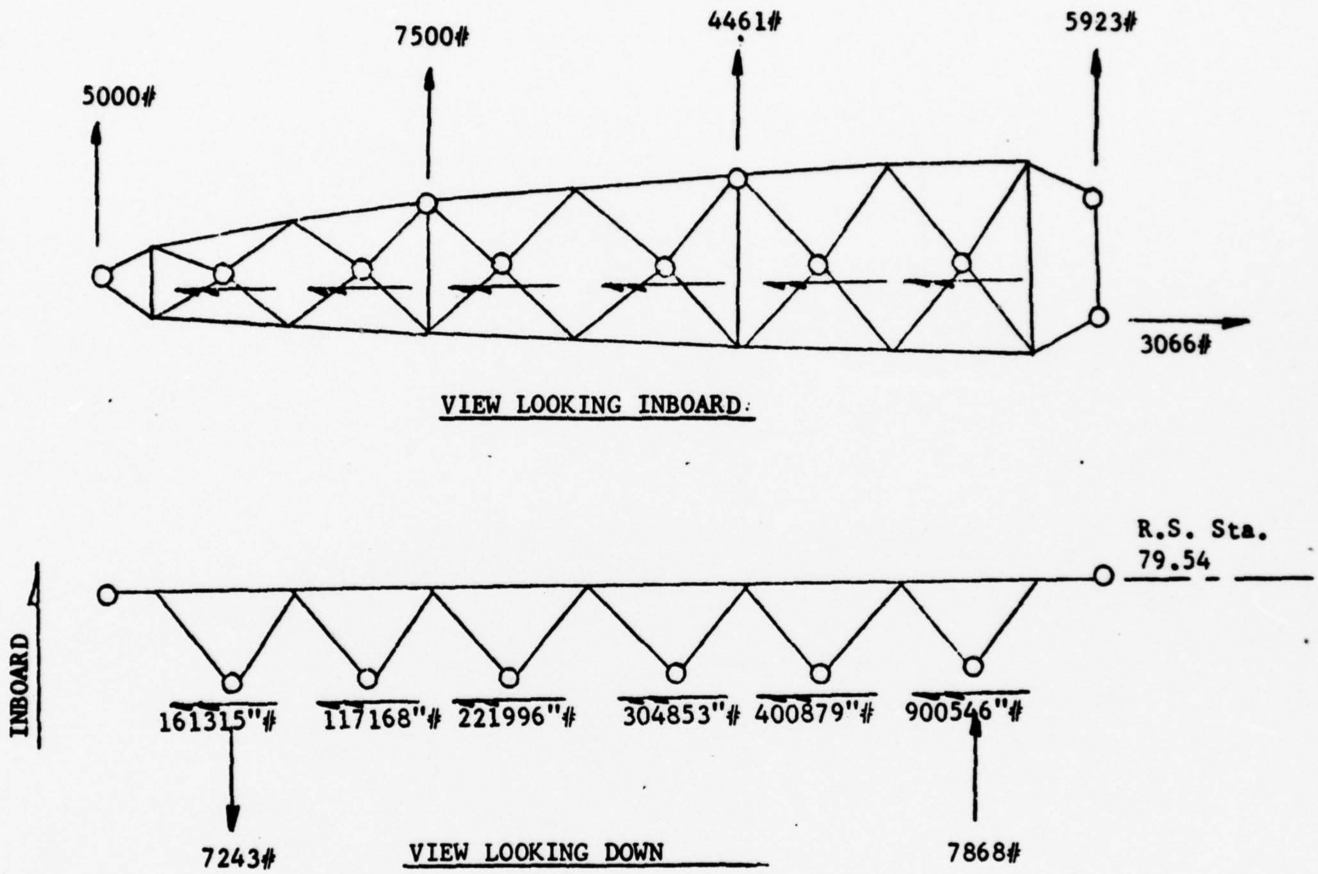
Axial and rosette strain gages were located at selected locations on the wing box cover skins and spars as shown in Figure C-18. Graphite/epoxy cover skin strains were measured with rosette gages at twelve locations (gages 1 through 12) on the upper and lower mold line surfaces of the wing box as specified in Figure C-18. Rosette gages were also located on the inner cover skin surfaces at gage locations 1 and 5. The "A" leg of these rosette gages was mounted parallel to the rear spar plane with the exception of gage 12 which was mounted parallel to the front spar plane.



(MAX. OPERATIONAL LOADS SHOWN)
= 150% D.L.L.

NOTE: Loads @ R.S. Sta. 79.54 are in R.S. Sta. 79.54 plane and are located @ intersection of W.R.P. and aft inter. spar plane. Aft wing-to-fuselage attach loads @ Pt. "O" are in Fuse. Ref. System.

Figure C-9 Maximum Vertical Landing Condition Test Loads (Ultimate Loads)



Loads applied to wing at R.S. Station 79.54 as shown. R.H. rule applies for moments acting on structure.

Note: R.S. Sta. 79.54 loads to be applied to TT-18636 test fixture lugs.

Figure C-10 Distribution of R.S. Sta. 79.54 Test Loads - Maximum Vertical Landing Condition (Ultimate Loads)

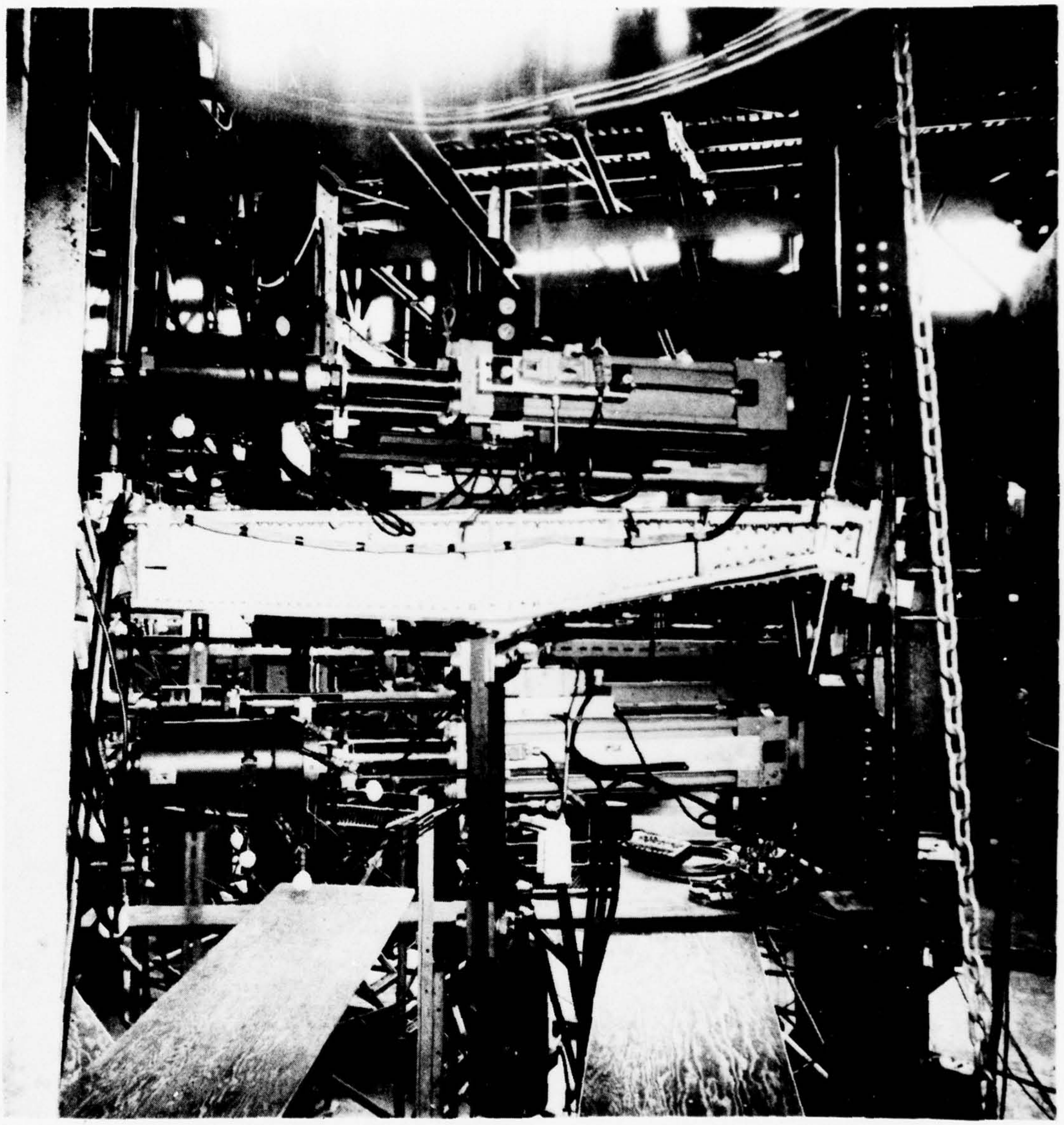


Figure C-11 View Looking Forward @ Test Setup

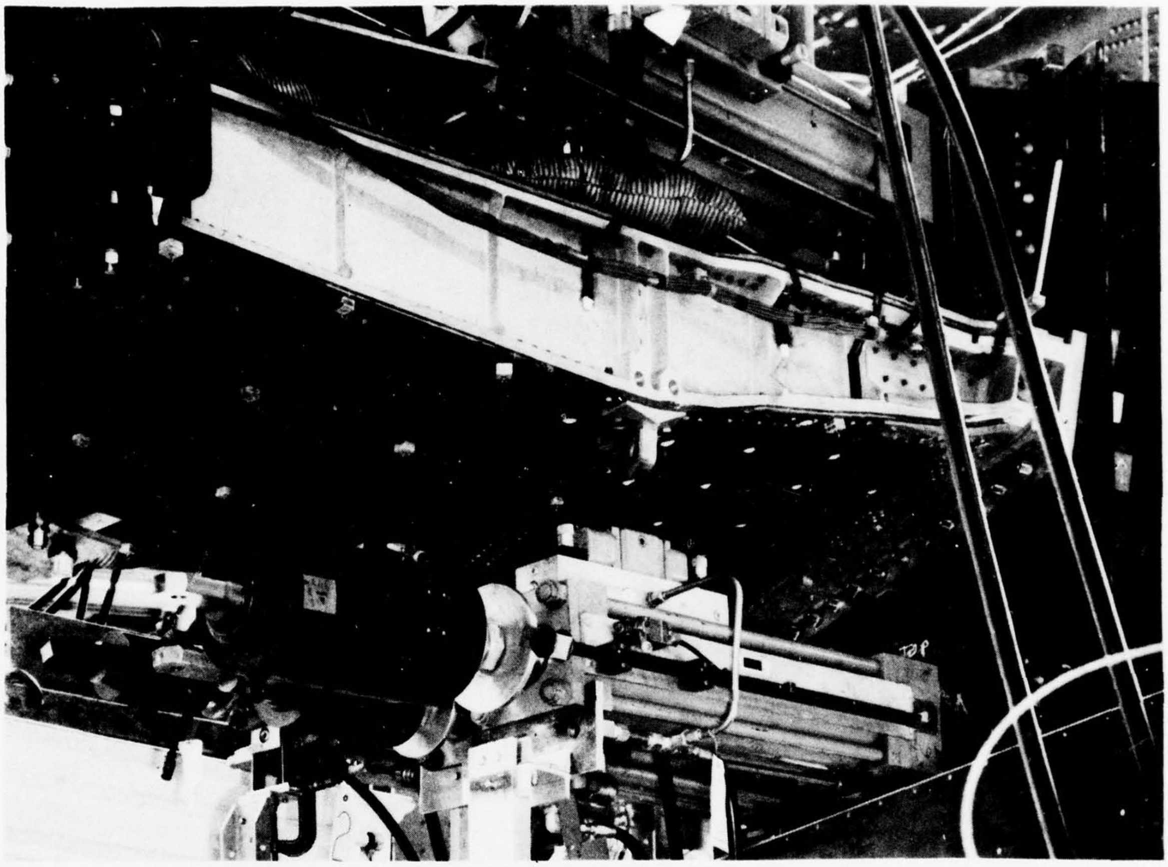
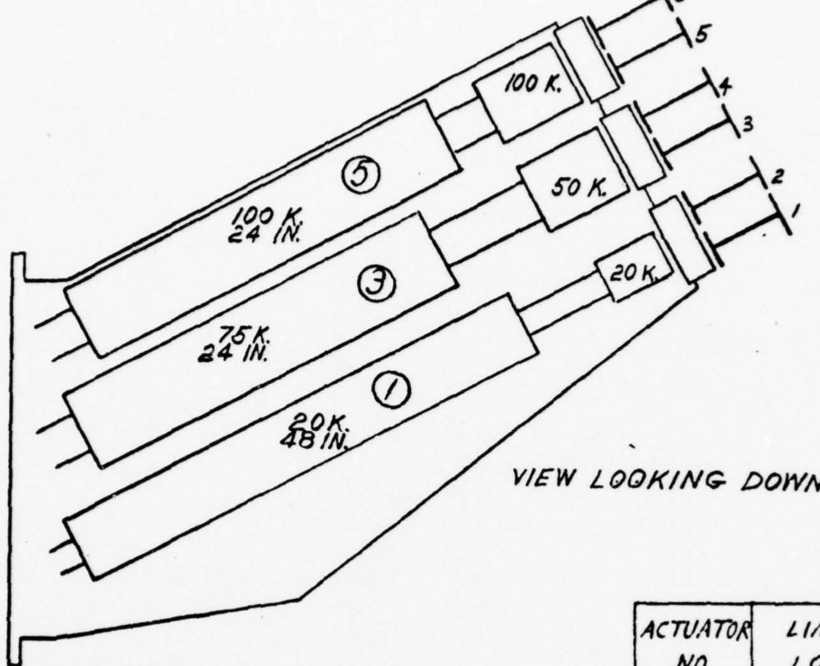


Figure C-12 View Looking Forward, Up, and Inboard @ Partial Test Setup



ACTUATOR NO.	LIMIT LOAD
1	+3050
2	-7880
3	+8360
4	-8360
5	+23280
6	-18040

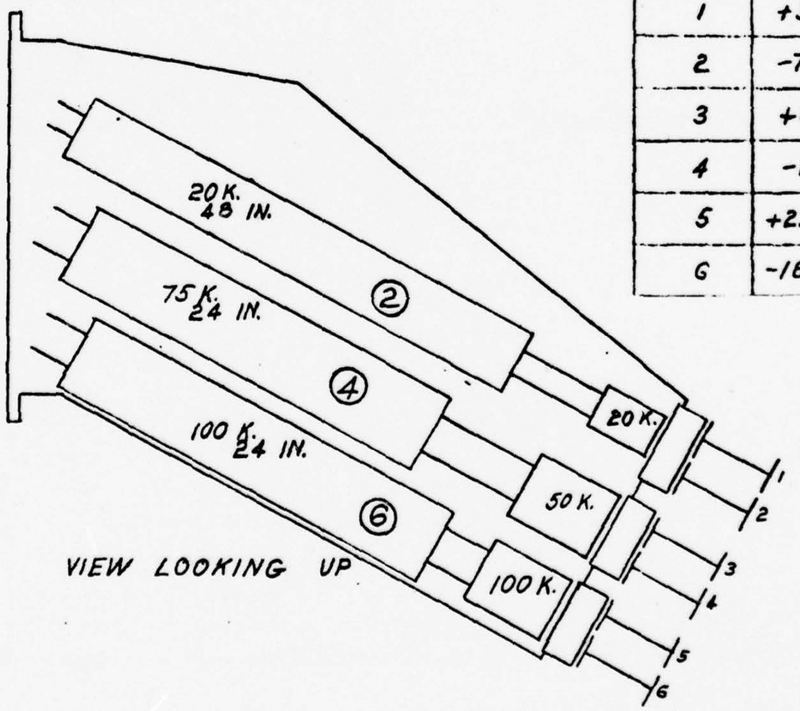
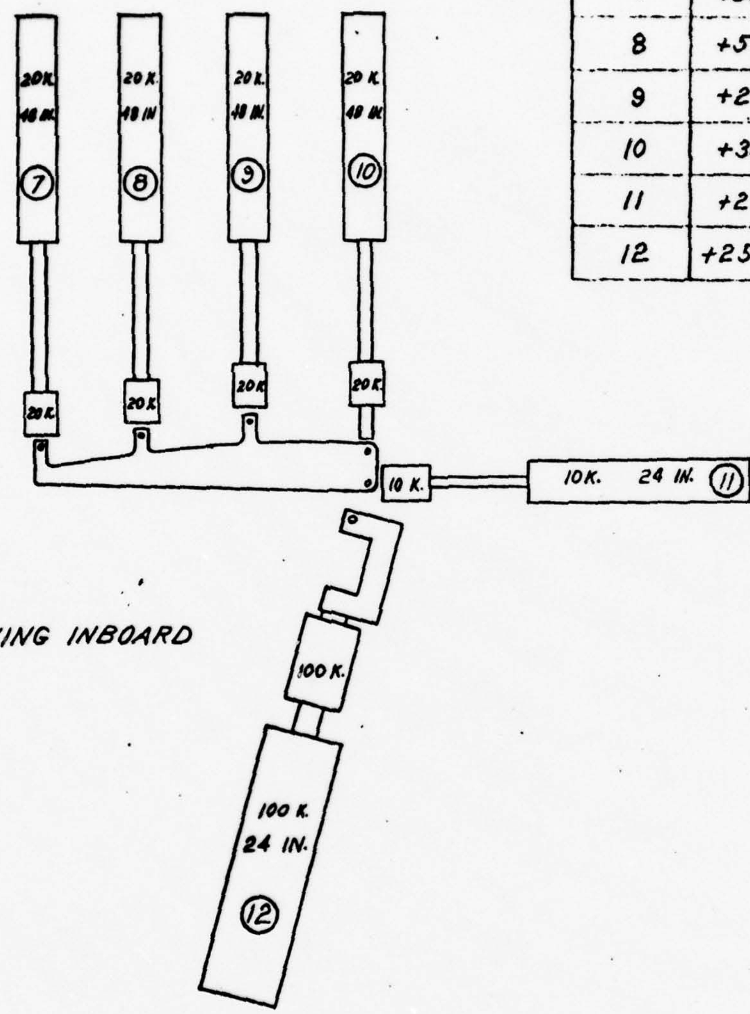


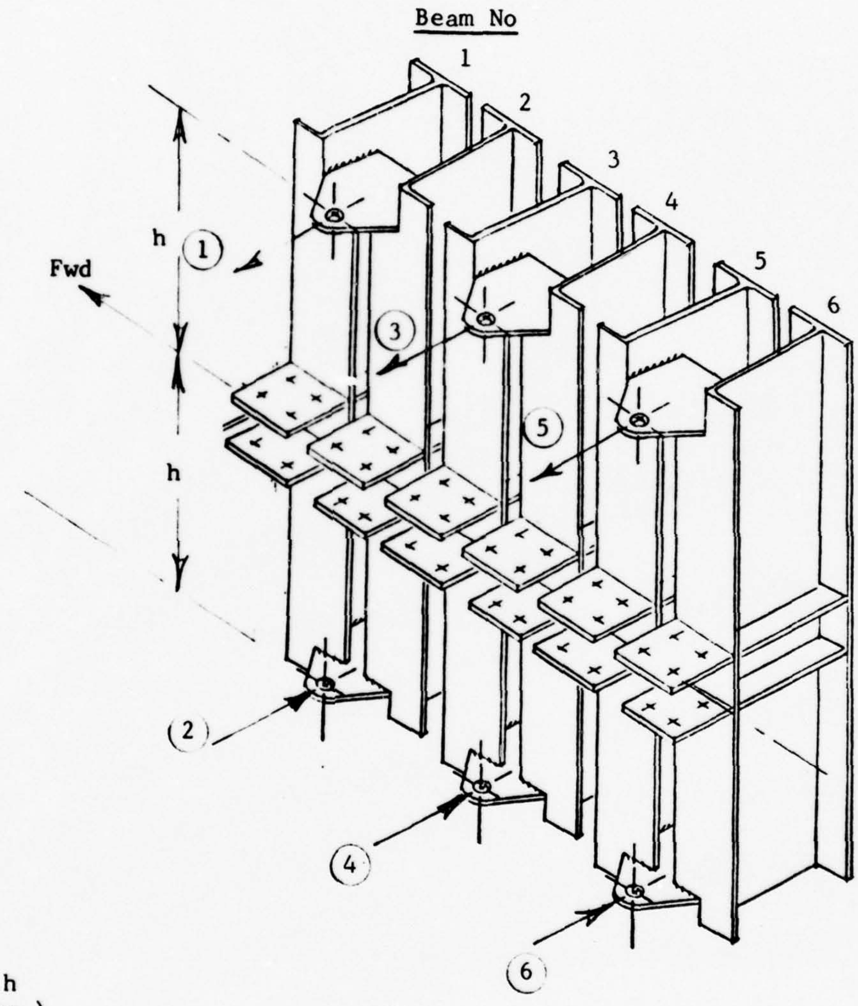
Figure C-13 Hydraulic Actuators and Load Cells - Number 1 through 6

ACTUATOR No.	LIMIT LOAD
7	+3330
8	+5000
9	+2970
10	+3950
11	+2040
12	+25440



VIEW LOOKING INBOARD

Figure C-14 Hydraulic Actuators and Load Cells - Number 7 through 12



Actuator No.	h (in.)
1	17
2	17
3	21
4	21
5	21
6	21

Figure C-15 Tip Moment Loading Fixture

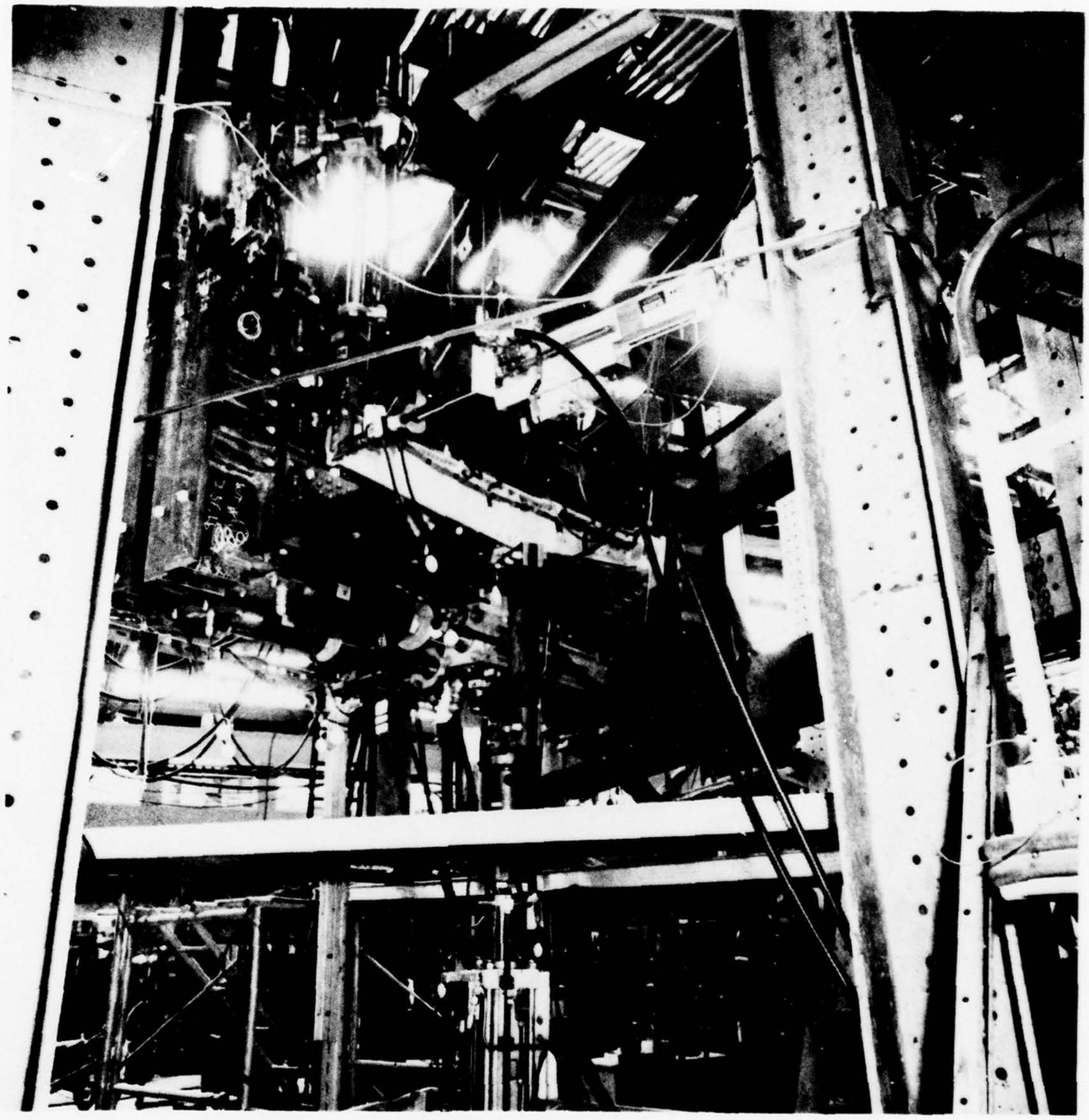


Figure C-16   View Looking Forward, Up, and Inboard @ Overall Test Setup

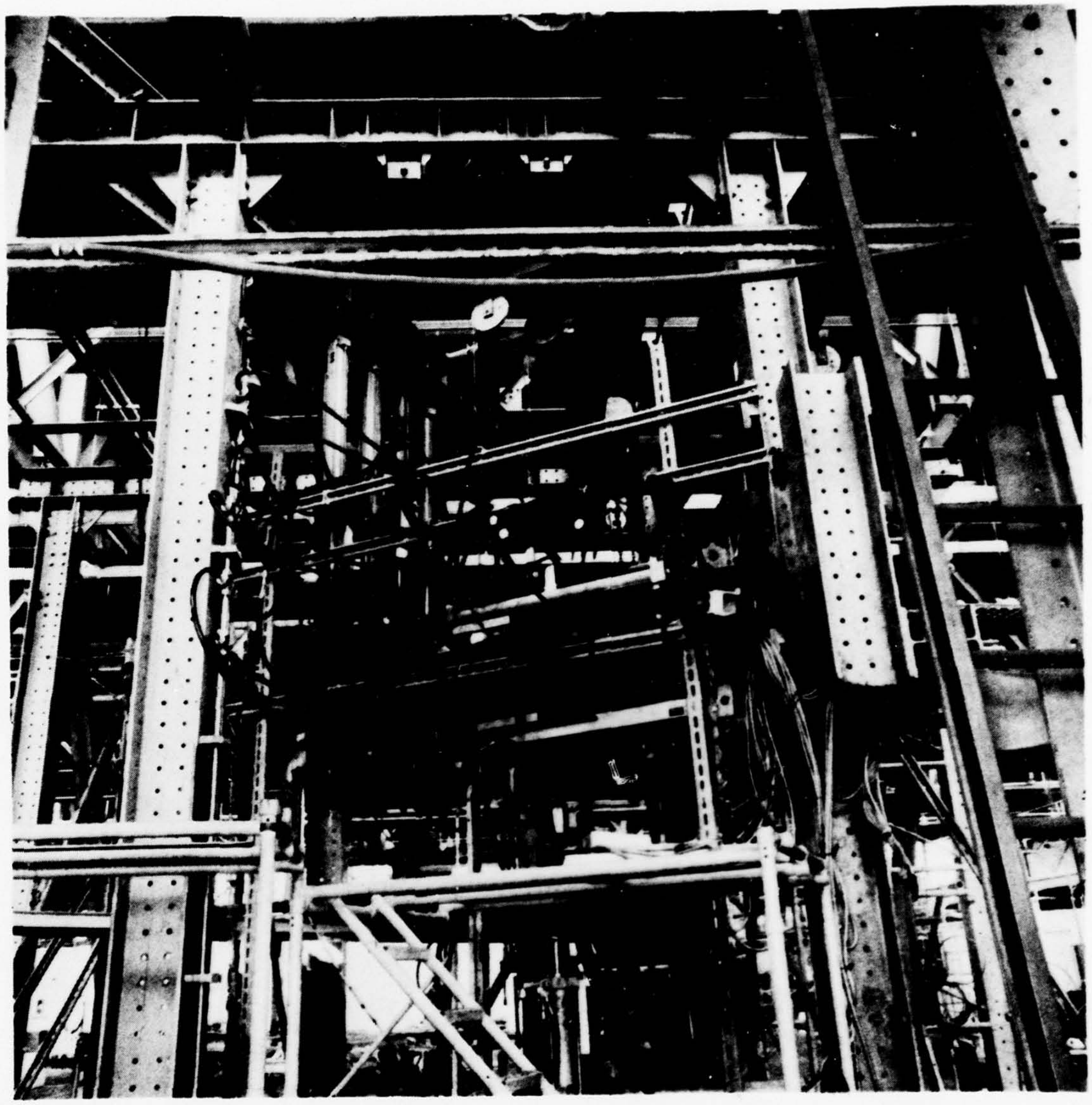
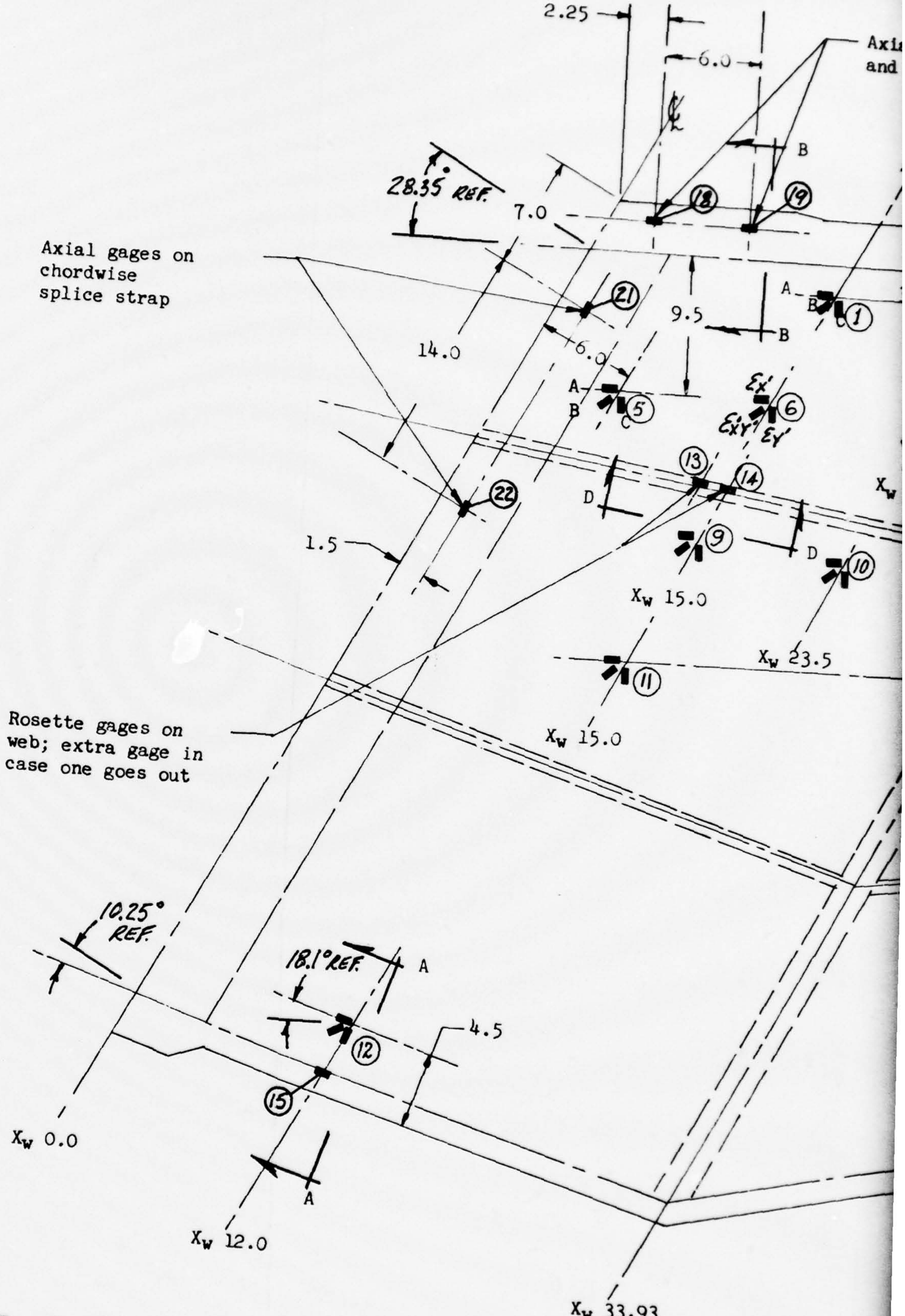


Figure C-17 View Looking Aft and Up @ Overall Test Setup



NOTE: All cover rosette gages oriented as shown with one leg parallel to rear spar plane except (12); typical upper and lower covers.

Gages (1) and (5) to be gages, upper and lower

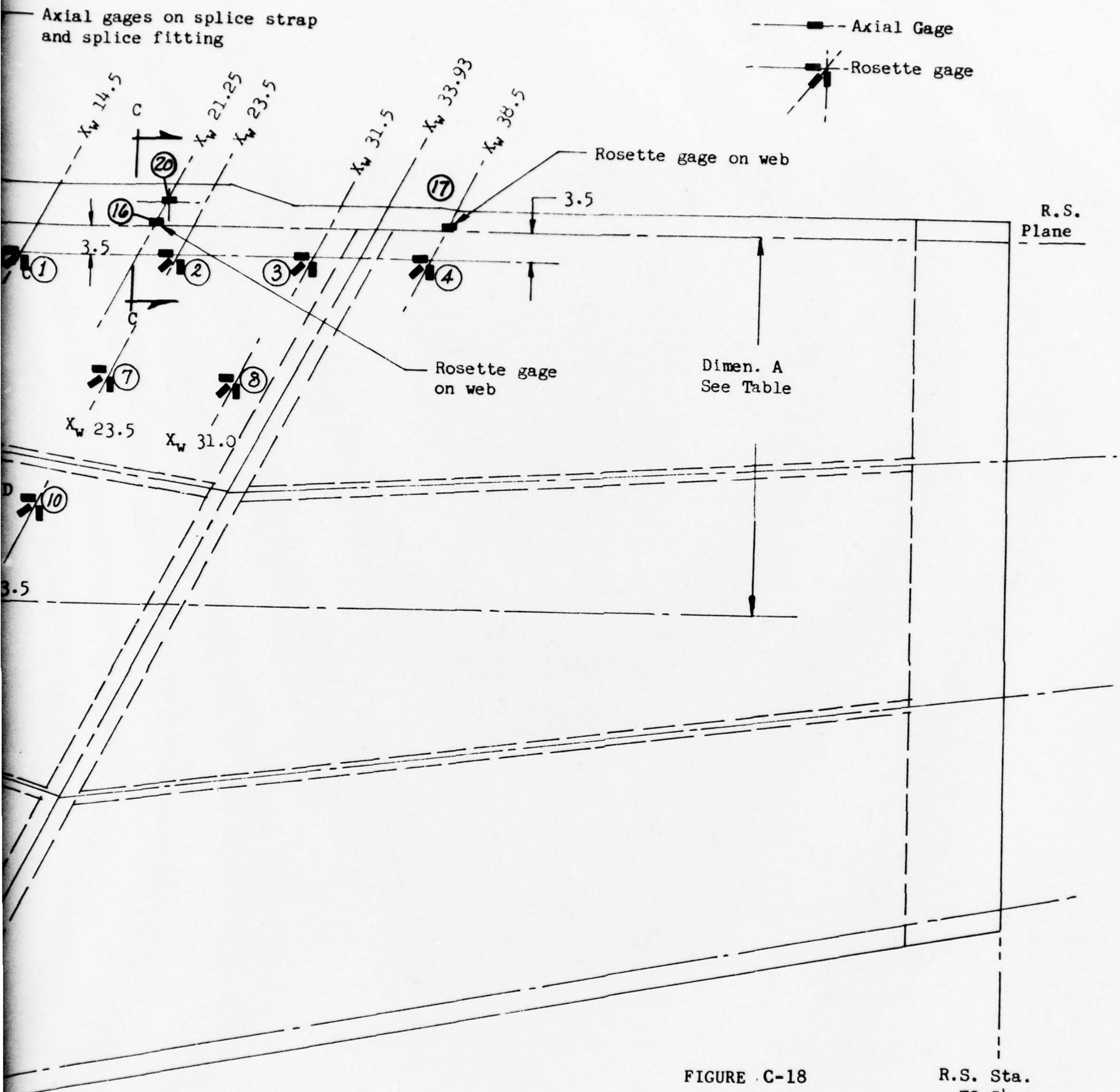
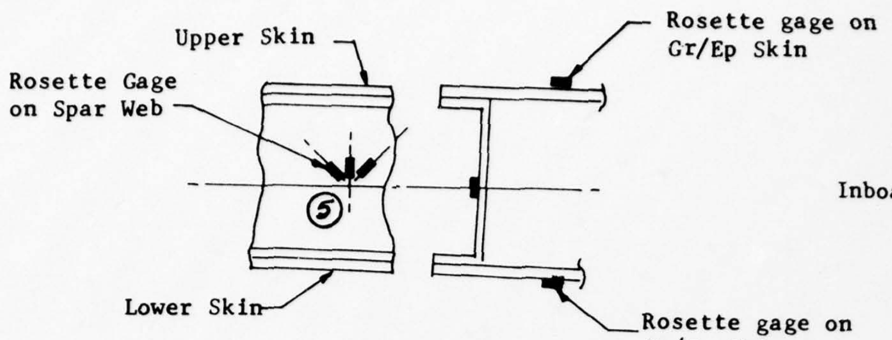


FIGURE C-18

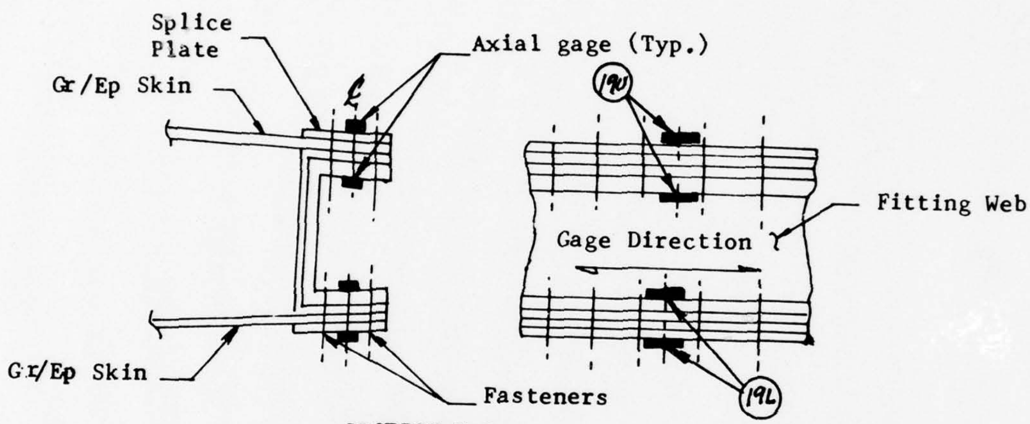
STRAIN GAGE LOCATIONS
Sheet 1 of 2

(5) to be back-to-back
nd lowe: covers.

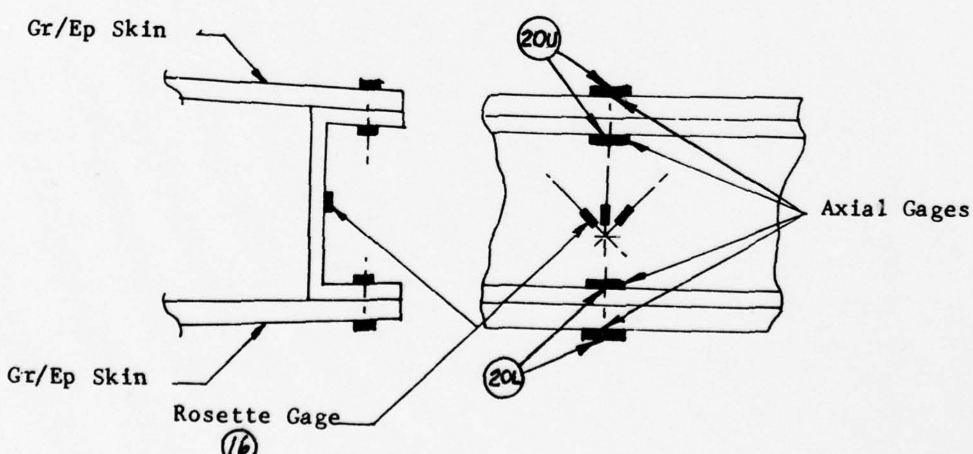
2



SECTION A-A

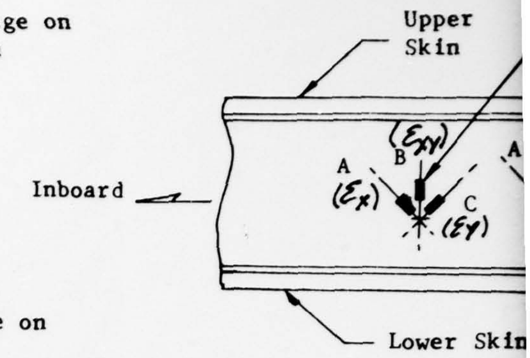


SECTION B-B



SECTION C-C

* UA denotes upper skin rosette leg A
LB denotes lower skin rosette leg B
SA denotes spar web rosette leg A

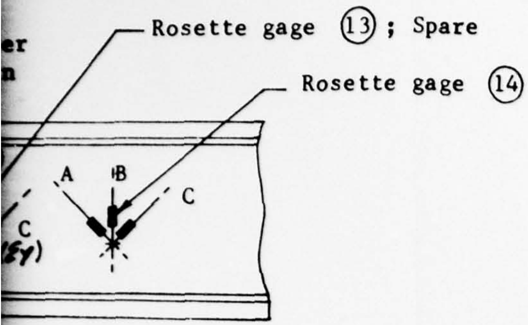


SECTION D-D

LO
GAGE NO.
1 UA*
1 UB
1 UC
1 LA
1 LB
1 LC
2
3
4
5 UA
5 UB
5 UC
5 LA
5 LB
5 LC
6
7
8
9
10
11
12
13SA
13SB (Spa
13SC
14SA
14SB
14SC

STRA

1



r Skin

ON D-D

LOCATION DIMENSIONS FOR ROSETTE STRAIN GAGES		
GE NO.	X_w	DIMENSION A, inches
JA* JB JC LA LB LC	14.5	3.5
	23.5	3.5
	31.5	3.5
	38.5	3.5
JA JB JC A B C	6.0	9.5
	14.5	9.5
	23.5	10.5
	31.0	11.0
	15.0	18.0
	23.5	19.0
	15.0	25.5
	12.0	See Sht 1 of 1
A B (Spare) C	Just inboard of gage 14	On aft intermediate spar web
A B C	14.5	On aft intermediate spar web

FIGURE C-18 Concluded

STRAIN GAGE LOCATIONS

Sheet 2 of 2

2

C-4-2 Strain Gage Locations (Cont'd.)

Gages 13 through 17 are rosette gages located on the webs of the front spar, aft intermediate spar and aluminum rear spar.

Gage locations 18 , 19 , and 20 are axial gages mounted on the upper and lower caps of the aluminum rear spar and aluminum rear spar splice joint.

Gage locations 21 and 22 are axial gages mounted on the upper and lower caps of the aluminum centerline rib splice plate.

C-4-3 Deflection Transducer Locations

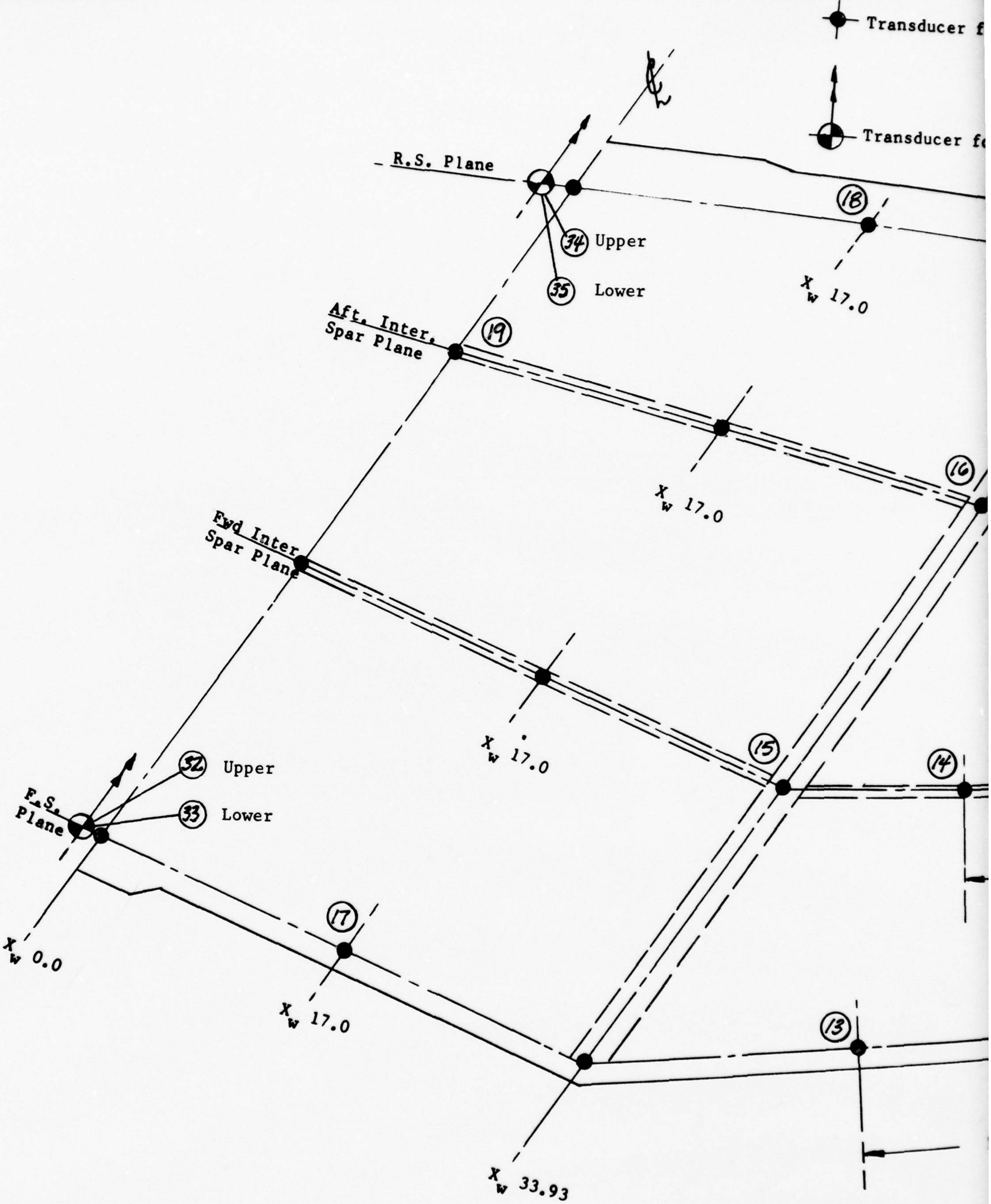
Vertical deflections of the lower surface of the wing box relative to a ground plane were measured at nineteen locations (transducer 1 through 19) as shown on Figure C-19. Measurements were obtained with deflection transducers attached by wires to small blocks bonded to the lower cover which are visible in the photo of Figure C-12.

Rotation at the tip of the wing box structure along the chord of R.S. Sta. 79.54 was measured with twelve deflection transducers (transducer 20 through 32) mounted to the tip loading fixture as shown in Figure C-20.

Rotation of the root support was measured with deflection transducers (transducers 32 through 35) located at the front and rear spar junction with the centerline rib. Root rotation was determined by measurement of the inboard-outboard movement at the end of tubes bonded to the upper and lower surfaces of the root rib. Deflections were measured at points fifteen inches above and below the wing reference plane.

C-4-4 Load Application and Data Collection

All loads were applied with computer programmed commands to the hydraulic loading jacks and monitored with continuous feed back from the corresponding load cells. Each of the twelve loading jacks were balanced to within one percent of the prescribed load level at each increment of load prior to recording strain and deflection measurements. Approximately 145 channels of strain and deflection data were recorded on magnetic tape and printed on paper tape while holding load at each loading increment. Transducers indicating locations of peak strain and deflection were manually monitored at each loading increment for any evidence of non-linear behavior.



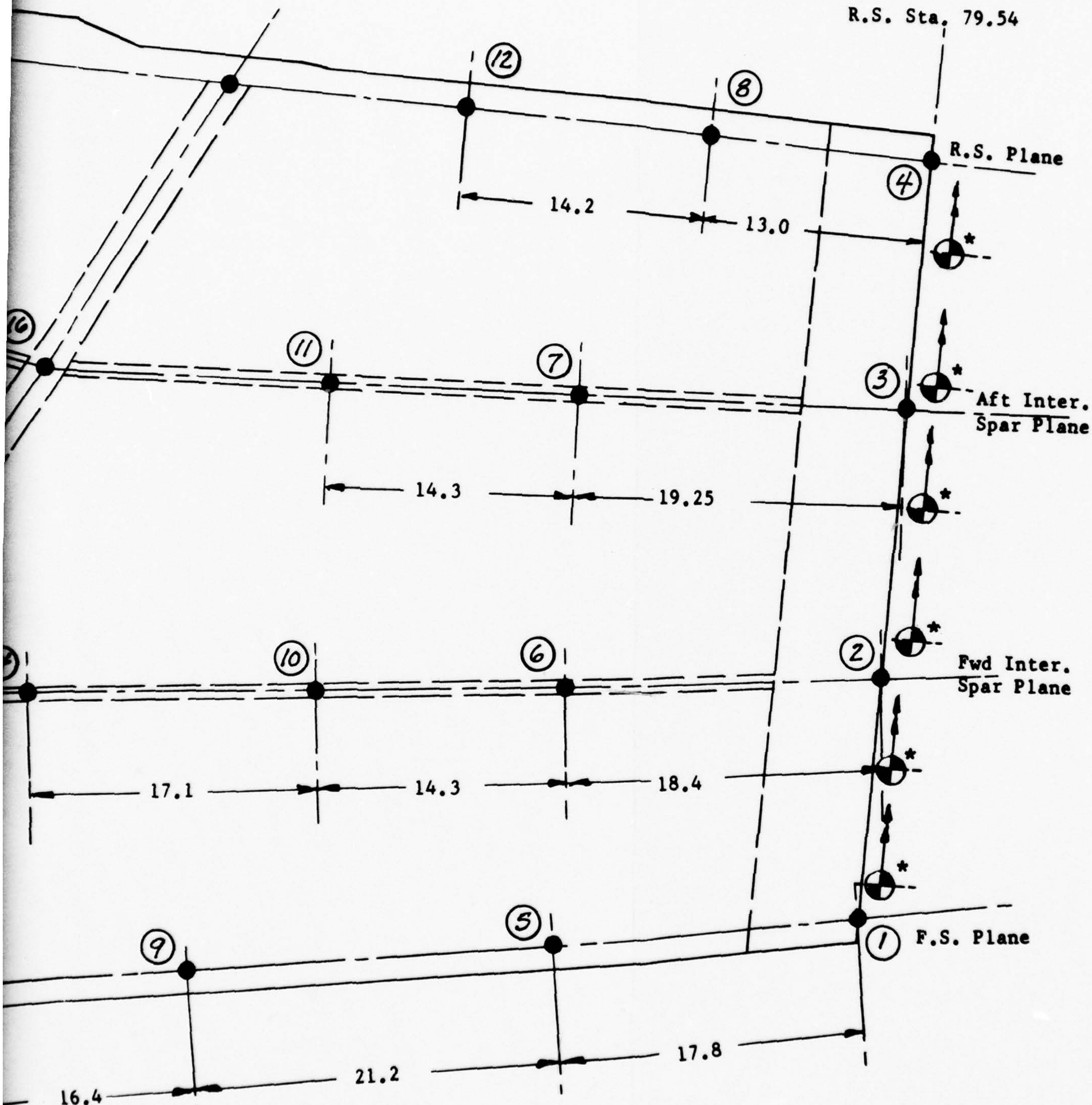
Transducer f
Transducer fo
R.S. Plane
34 Upper
35 Lower
18
X_w 17.0
Aft. Inter. Spar Plane
19
16
X_w 17.0
Fwd Inter Spar Plane
X_w 17.0
15
14
32 Upper
33 Lower
F.S. Plane
17
X_w 0.0
X_w 17.0
13
X_w 33.93

for bending deflection

for bending rotation

NOTES:

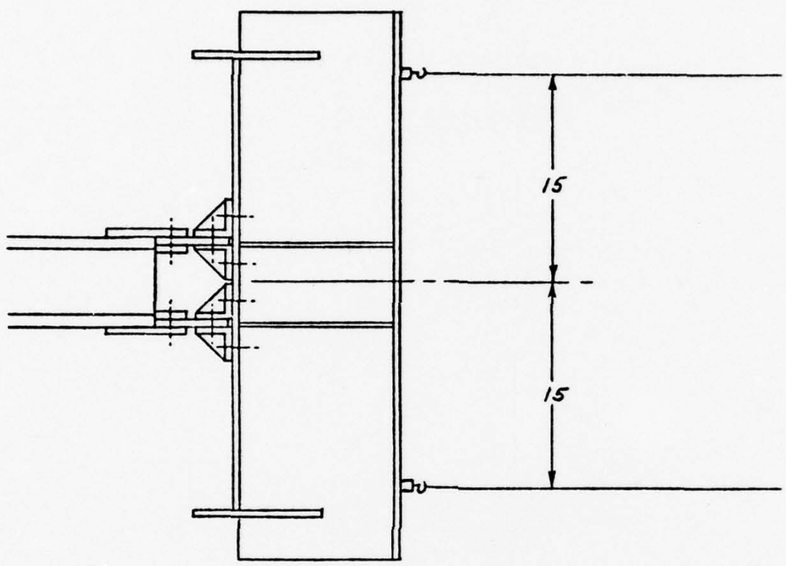
1 All deflection transducers are located on front spar, rear spar, or inter. spar lines and are located at NASTRAN node points.



*Attach to I-Beams used for bending moment application.

FIGURE C-19 DEFLECTION TRANSDUCER LOCATIONS

2



Top	
Beam	Number
1	20
2	22
3	24
4	26
5	28
6	30

Bottom	
Beam	Number
1	21
2	23
3	25
4	27
5	29
6	31

Figure C-20 Tip Rotation Transducer Locations

C.5 STATIC TEST RESULTS

C.5.1 Strain and Deflection Measurements

Static test loadings to 100% of design limit load were completed on 8 August 1978 and static test loadings to 150% of design limit load were completed on 9 August 1978.

Strain and deflection measurements for the 100% load test are presented in Table C.1. Loading increments for this test were 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 80, 60, 40, 20, 0 percent of limit load. Channel numbers are assigned to each strain gage leg as indicated in the table. Strain gage numbering code is as follows:

1 AU_o denotes strain gage location 1 (Ref. Fig. C-18) "A" leg of strain gage (Ref. Fig. C-18), Outer surface of upper skin

5 BL_i denotes strain gage location 5 "B" leg of strain gage, Inner surface of lower skin

Strain and deflection measurements for the 150% load test are presented in Table C-2. Loading increments for this test were 0, 20, 40, 60, 80, 100, 110, 120, 130, 140, 150, 140, 120, 100, 80, 60, 40, 20, 0 percent of limit load.

Exceptional linearity and repeatability of strains and deflections are evident in both the 100% and 150% load test data. Plots of the maximum reading cover strain gages (Gage 1 AU_o and Gage 2 AU_o) and the peak deflection gage (Transducer 1) are presented in Figures C-21 and C-22 respectively. These plots show consistent linearity throughout the entire range of loadings from 0 to 150%. These plots also show the repeatability of the strain and deflection behavior between the 100% and 150% load test applications. The 150% D.L.L. strains for Rosette Gage $1U_o$ resulted in the highest recorded laminate normal principal stress. This peak stress value was -32,644 psi which compared favorably with the 35,000 psi maximum design goal mutually agreed upon by Rockwell and the Navy program monitor as a conservative stress limit to account for environmental degradation and material property scatter effects which might be encountered in a production aircraft fleet.

Table C-3 presents a comparison of all strain gage readings at 100% limit load as taken from the strain data of Tables C-1 and C-2. This comparison shows that the strain measurements recorded during 9 August 1978 test loadings were essentially identical to those taken during the 8 August test loadings at all strain gage locations.

Figures C-23 and C-24 present overall views of the upper and lower cover skin and rear spar cap strains at 150% D.L.L.

Ref. Fig. C-18

TABLE C.1

XFV-12A WING BOX LIMIT LOAD TEST STRAINS AND DEFLECTIONS (micro inches per inch)

Channel No.	Gage No.	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
000	$1AU_o$	0	-223	-442	-663	-890	-1129	-1375	-1611	1856	-2085	-2334
001	$1BU_o$											
002	$1CU_o$	0	+138	+272	+402	+534	+670	+810	+939	+1070	+1188	+1322
003	$1AU_i$	0	-186	-369	-552	-739	-934	-1133	-1327	-1520	-1706	-1905
004	$1BU_i$	0	+2	+9	+19	+32	+47	+67	+93	+122	+147	+174
005	$1CU_i$	0	+112	+222	+331	+444	+560	+679	+798	+912	+1024	+1141
006	$2AU_o$	0	-238	-471	-706	-943	-1188	-1438	-1680	-1928	-2170	-2425
007	$2BU_o$	0	-17	-35	-52	-68	-85	-78	-117	-132	-145	-158
008	$2CU_o$	0	+175	+348	+520	+692	+869	+1050	+1218	+1399	+1569	+1756
009	$3AU_o$	0	-149	+4	-418	-571	-718	-873	-1037	-1173	-1265	-2262
010	$3BU_o$	0	-24	-48	-71	-94	-118	-141	-162	-182	-202	-220
011	$3CU_o$	0	+64	+126	+189	+251	+315	+381	+444	+509	+570	+629
012	$4AU_o$	0	-205	-412	-175	-838	-2295	-1256	-1415	-1679	1882	-2103
013	$4BU_o$											
014	$5AU_o$	0	-228	-331	-336	-498	-509	-621	-737	-880	-1012	-1140
015	$4CU_o$											
016	$5BU_o$											
017	$5CU_o$	0	+38	+73	+109	+132	+187	+182	+165	+146	+149	+171
018	$5AU_i$	0	-95	-186	-273	-356	-438	-504	-544	-601	-668	-734
019	$5BU_i$	0	-14	-28	-39	-43	-44	-28	-7	13	-15	-14
020	$5CU_i$	0	+28	+57	+82	+105	+126	+154	+186	+223	+256	+286
021	$6AU_o$	0	-203	-398	-593	-788	-989	-1195	-1382	-1577	-1763	-1958
022	$6BU_o$	0	+3	+6	+10	+19	+27	+39	+57	+63	+72	+84
023	$6CU_o$	0	+111	+218	+321	+420	+519	+623	+707	+794	+879	+969
024	$7AU_o$	0	-213	-426	-637	-848	-1068	-1294	-1506	-1729	-1944	-2174
025	$7BU_o$	0	0	-2	-3	-3	-5	-5	-4	-7	-11	-17
026	$7CU_o$	0	+133	+264	+391	+516	+643	+775	+889	+1015	+1131	+1258
027	$8AU_o$	0	-138	-275	-410	-548	-691	-837	-971	-1112	-1246	-1389
028	$8BU_o$	0	+3	+6	+11	+16	+19	+26	+32	+42	+49	+61
029	$8CU_o$	0	+90	+180	+268	+356	+445	+537	+621	+715	+802	+896
030	$9AU_o$	0	-208	-412	-609	-800	-994	-1189	-1370	-1562	-1750	-1939
031	$9BU_o$	0	-19	-38	-56	-75	-94	-111	-131	-145	-162	-179

90%	100%	80%	60%	40%	20%	0%
-2083	-2334	-1905	-1441	-979	-505	-44
+1188	+1322	+1092	+835	+564	+282	-4
-1706	-1905	-1552	-1170	-781	-396	-13
+147	+174	+115	+67	+30	+10	+6
+1024	+1141	+933	+704	+464	+223	-18
-2170	-2425	-1962	-1477	-991	-509	-27
-145	-158	-150	-129	-101	-65	-18
+1569	+1756	+1436	+1094	+743	+388	+23
-1265	-2262	-1186	-396	-580	-107	-5
-202	-220	-184	-142	-97	-50	-3
+570	+629	+519	+401	+277	+148	+8
1882	-2103	-1714	-1280	-852	-169	-13
-1012	-1140	-938	-708	-460	-197	+80
+149	+171	+161	+137	+80	+139	-51
-668	-734	-595	-436	-262	-75	+111
-15	-14	-19	-26	-30	-23	+4
+256	+286	+268	+237	+196	+140	+63
-1763	-1958	-1613	-1235	-838	-432	-11
+72	+84	+44	+9	-18	-34	-31
+879	+969	+817	+641	+445	+225	-18
-1944	-2174	-1774	-1351	-917	-479	-29
-11	-17	-17	-17	-17	-15	-8
+1131	+1258	+1053	+825	+578	+312	+19
-1246	-1389	-1132	-861	-583	-304	-19
+49	+61	+48	+36	+25	+15	+5
+802	+896	+741	+573	+399	+217	+20
-1750	-1939	-1608	-1247	-869	-470	-37
-162	-179	-146	-109	-76	-44	-12

TABLE C.1 (Cont'd.)

XFV-12A WING BOX
LIMIT LOAD TEST
STRAINS AND
DEFLECTIONS
(micro inches
per inch)

Ref. Fig. C-18

Channel No.	Gage No.	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	8
032	9CU₀	0	+96	+191	+279	+359	+436	+512	+572	+656	+729	+802	+6
033	10AU₀	0	-188	-374	-557	-737	-922	-1110	-1282	-1467	-1645	-1828	-15
034	10BU₀	0	-46	-91	-132	-173	-215	-256	-294	-331	-369	-402	-3
035	10CU₀	0	+102	+203	+301	+394	+486	+581	+664	+761	+852	+947	+8
036	11AU₀	0	-188	-375	-558	-736	-919	-1106	-1285	-1452	-1657	-1841	-15
037	11BU₀	0	-31	-62	-96	-131	-169	-212	-262	-302	-348	-394	-3
038	11CU₀												
039	12AU₀												
040	12BU₀												
041	12CU₀	0	+57	+112	+168	+222	+278	+336	+389	+441	+491	+547	+4
042	21U₀*												
043	22U₀	0	-20	-45	-71	-93	-113	-121	-115	-143	-167	-185	-16
044	18U₀	0	-109	-219	-333	-453	-580	-694	-811	-940	-1072	-1197	-9
045	19U₀	0	-136	-269	-404	-545	-693	-824	-949	-1064	-1191	-1296	-10
046	19Uᵢ⊛	0	-53	-102	-153	-203	-252	-296	-342	-382	-435	-467	-35
047	20U₀△	0	-200	-396	-591	-790	-994	-1187	-1385	-1587	-1784	-1977	-15
048	20Uᵢ	0	-147	-291	-435	-581	-733	-884	-1029	-1172	-1318	-1464	-11
049	BLANK												
050	13AS	0	-105	-203	-297	-391	-487	-586	-690	-788	-895	-983	-80
051	13BS	0	-36	-67	-94	-122	-153	-180	-207	-245	-286	-329	-25
052	13CS												
053	14AS	0	-72	-163	-249	-335	-423	-517	-614	-708	-807	-891	-72
054	14BS	0	-34	-65	-92	-121	-155	-192	-230	-278	-325	-375	-29
055	14CS	0	+83	+163	+242	+321	+399	+474	+552	+625	+700	+759	+63
056	15AS	0	+27	+54	+78	+102	+124	+161	+199	+249	+289	+329	+29
057	15BS	0	-9	-18	-25	-30	-33	-32	-23	-15	-10	-7	-5
058	15CS	0	-8	-17	-25	-34	-42	-62	-79	-102	-121	-141	-13
059	16AS	0	-8	-17	-29	-44	-63	-79	-97	-113	-129	-141	-12
060	16BS	0	+10	+20	+28	+39	+50	+60	+70	+80	+89	+98	+8
061	16CS	0	-4	-10	-11	-13	-11	-11	-10	-10	-11	-8	+2
062	17AS	0	-27	-55	-84	-112	-139	-167	-194	-221	-251	-287	-2
063	17BS	0	+13	+25	+38	+55	+71	+91	+110	+129	+147	+165	+13

* denotes upper cap outer surface

⊛ denotes upper cap inner surface

△ located on upper cover oute

80%	60%	40%	20%	0%
+695	+570	+425	+251	+29
-1510	-1163	-803	-427	-28
-339	-266	-187	-104	-11
+800	+636	+458	+259	+27
-1525	-1184	-835	-466	-56
-316	-236	-159	-91	-25
+450	+345	+237	+126	+17
-169	-146	-115	-69	-13
-975	-730	-486	-261	-45
-1017	-717	-424	-154	+90
-350	-236	-136	-54	+9
-1586	-1180	-776	-378	+15
-1171	-868	-569	-274	+13
-802	-596	-394	-195	-7
-251	-169	-98	-35	+13
-721	-531	-344	-160	+11
-294	-210	-135	-66	-6
+633	+482	+326	+166	-3
+299	+264	+220	+162	+72
-5	-4	0	+7	+21
-138	-133	-123	-101	-58
-127	-90	-59	-33	-18
+82	+63	+42	+23	+6
+2	0	-1	+5	+19
-231	-169	-110	-51	+3
+132	+97	+61	+31	+5

outer surface

1

2

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TABLE C.1 (Cont'd.)

XFV-12A WING BOX
LIMIT LOAD TEST
STRAINS AND
DEFLECTIONS
(micro inches per inch)

Ref. Fig. C-18

Channel No.	Gage No.	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
064	17CS											
100	1AL o	0	+199	+400	+603	+810	+1019	+1232	+1441	+1654	+1859	+2066
101	1BL o	0	-10	-21	-32	-44	-57	-70	-83	-97	-111	-126
102	1AL i	0	+179	+361	+544	+731	+922	+1117	+1308	+1502	+1688	+1875
103	1CL o											
104	1BL i	0	-14	-28	-43	-60	-76	-96	-112	-129	-142	-155
105	1CL i	0	-116	-233	-354	-476	-604	-738	-862	-994	-1115	-1244
106	2AL o	0	+214	+427	+637	+849	+1063	+1278	+1489	+1702	+1913	+2134
107	2BL o	0	0	+1	+4	+6	+7	+7	+9	+7	+7	+5
108	2CL o	0	-152	-305	-456	-610	-770	-932	-1086	-1253	-1411	-1586
109	3AL o	0	+156	+308	+459	+611	+765	+914	+1064	+1215	+1366	+1518
110	3BL o	0	+18	+34	+46	+59	+71	+82	+95	+103	+115	+123
111	3CL o	0	-79	-162	-251	-344	-440	-541	-634	-736	-829	-932
112	4AL o	0	+169	+338	+507	+682	+861	+1033	+1205	+1382	+1556	+1728
113	4BL o	0	+30	+63	+96	+130	+162	+180	+202	+213	+231	+239
114	4CL o	0	-63	-132	-203	-274	-346	-429	-509	-597	-680	-770
115	5AL o	0	+114	+227	+334	+440	+547	+655	+764	+872	+981	+1084
116	5BL o	0	+11	+22	+31	+37	+44	+60	+80	+104	+123	+145
117	5CL o											
118	5AL i	0	+98	+196	+294	+395	+496	+589	+678	+761	+854	+936
119	5BL i	0	-22	-43	-60	-77	-96	-121	-143	-172	-190	-210
120	5CL i	0	-29	-54	-75	-92	-111	-133	-150	-171	-187	-199
121	6AL o	0	+192	+379	+566	+752	+943	+1131	+1315	+1503	+1689	+1871
122	6BL o	0	+4	+8	+9	+7	+4	0	-4	-8	-13	-19
123	6CL o	0	-86	-169	-252	-337	-425	-514	-595	-682	-770	-860
124	7AL o											
125	7BL o	0	+17	+33	+46	+58	+69	+77	+84	+91	+98	+104
126	7CL o	0	-131	-264	-396	-531	-670	-812	-945	-1089	-1238	-1377
127	8AL o	0	+87	+177	+269	+354	+445	+533	+612	+706	+713	+880
128	8BL o	0	-14	-29	-44	-60	-77	-100	-121	-147	-169	-196
129	8CL o	0	-94	-188	-283	-379	-477	-578	-672	-772	-869	-972
130	9AL o	0	+173	+344	+509	+673	+839	+1003	+1163	+1324	+1486	+1639

00%	80%	60%	40%	20%	0%
2066	+1694	+1281	+861	+443	+25
126	-81	-45	-16	+4	+15
1875	+1535	+1160	+780	+402	+23
155	-122	-90	-58	-29	+2
1244	-1041	-805	-557	-304	-42
2134	+1735	+1312	+884	+453	+19
+5	+20	+23	+24	+20	+9
1586	-1291	-977	-658	-341	-25
1518	+1227	+924	+617	+308	-4
123	+104	+81	+59	+33	-3
932	-761	-574	-381	-193	-17
1728	+1399	+1053	+699	+348	+8
239	+206	+166	+115	+53	-6
-770	-629	-475	-326	-177	-19
1084	+892	+679	+459	+234	-2
145	+139	+134	+120	+92	+50
936	+763	+564	+363	+161	-46
210	-167	-118	-68	-21	+12
199	-179	-148	-111	-58	+5
1871	+1533	+1159	+778	+69	+2
-19	-2	+12	+22	+23	+14
860	-706	-532	-356	-177	+6
104	+95	+83	+62	+36	0
1377	-1155	-867	-593	-317	-34
880	+717	+544	+366	+186	0
196	-155	-114	-77	-44	-14
972	-805	-619	-429	-234	-30
1639	+1350	+1033	+707	+369	+13

TABLE C.1 (Cont'd.)

XFV-12A WING BOX
LIMIT LOAD TEST
STRAINS AND
DEFLECTIONS
(micro inches
per inch)

Ref. Fig. C-18

Ch. No.	Gage No.	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	80%	6
131	9BLo	0	+8	+15	+23	+31	+38	+45	+55	+65	+74	+86	+78	+6
132	9CLo	0	-74	-144	-211	-275	-340	-406	-467	-532	-594	-655	-554	-4
133	10ALo	0	+181	+360	+535	+709	+885	+1059	+1228	+1401	+1571	+1740	+1428	+10
134	10BLo	0	+35	+68	+99	+129	+159	+186	+214	+240	+267	+293	+246	+19
135	10CLo	0	-93	-187	-277	-365	-455	-547	-632	-722	-808	-898	-749	-5
136	BLANK	SEE	149											
137	11BLo													
138	11CLo													
139	12ALo													
140	12BLo	0	+88	+172	+252	+326	+398	+458	+516	+569	+625	+682	+555	+41
141	12CLo	0	-103	-207	-307	-404	-512	-599	-688	-780	-867	-960	-803	-62
142	21Lo*	0	-6	-13	-17	-21	-23	-21	-17	-19	-18	-23	-17	-1
143	22Lo	0	-1	+1	+3	+6	+10	+15	+20	+27	+29	+35	+33	+32
144	18Lo	0	+157	+317	+481	+650	+825	+1004	+1184	+1355	+1502	+1633	+1323	+97
145	19Lo	0	+167	+341	+517	+689	+855	+971	+1085	+1223	+1376	+1534	+1228	+89
146	19Li⊛	0	+53	+92	+131	+174	+222	+269	+319	+375	+438	+512	+409	+31
147	20LoΔ	0	+198	+389	+581	+776	+974	+1171	+1365	+1569	+1766	+1976	+1599	+12
148	20Li	0	+123	+244	+363	+482	+605	+726	+846	+968	+1089	+1210	+975	+72
149	11ALo	0	+155	+307	+454	+596	+741	+885	+1025	+1171	+1314	+1459	+1209	+93

* denotes lower cap outer surface

⊛ denotes lower cap inner surface

Δ located on lower cover outer surface

80%	60%	40%	20%	0%
+78	+67	+55	+43	+26
554	-439	-317	-179	-23
1428	+1090	+743	+386	+14
246	+193	+137	+75	+9
749	-583	-409	-224	-24
555	+419	+279	+134	-23
803	-625	-441	-244	-22
17	-13	-7	+3	+14
33	+32	+30	+26	+17
323	+975	+635	+314	+5
228	+892	+558	+239	-67
409	+311	+212	+122	+31
599	+1201	+802	+408	+17
975	+729	+482	+240	-2
209	+936	+653	+358	+40

TABLE C.1 (Concluded)
XFV-12A WING BOX
LIMIT LOAD TEST
DEFLECTIONS
(inches)

Deflection Transducer No (Ref. Fig. C-19 & C-20)	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
1	0	+0.20	+0.43	+0.61	+0.80	+1.03	+1.27	+1.45	+1.69	+1.89	+2.13
2	0	+0.21	+0.42	+0.59	+0.80	+1.00	+1.22	+1.40	+1.62	+1.83	+2.05
3	0	+0.20	+0.38	+0.56	+0.75	+0.95	+1.19	+1.35	+1.55	+1.75	+1.97
4	0	+0.16	+0.35	+0.50	+0.68	+0.88	+1.09	+1.23	+1.42	+1.61	+1.81
5	0	+0.13	+0.28	+0.43	+0.56	+0.71	+0.87	+1.01	+1.15	+1.32	+1.47
6	0	+0.12	+0.26	+0.41	+0.53	+0.68	+0.84	+0.96	+1.13	+1.27	+1.41
7	0	+0.11	+0.24	+0.37	+0.47	+0.60	+0.74	+0.85	+0.99	+1.12	+1.24
8	0	+0.12	+0.24	+0.36	+0.46	+0.59	+0.74	+0.86	+1.00	+1.12	+1.25
9	0	+0.06	+0.15	+0.24	+0.34	+0.41	+0.52	+0.60	+0.71	+0.80	+0.89
10	0	+0.12	+0.18	+0.30	+0.38	+0.49	+0.61	+0.69	+0.82	+0.92	+1.01
11	0	+0.08	+0.16	+0.25	+0.32	+0.40	+0.50	+0.59	+0.67	+0.76	+0.86
12	0	+0.05	+0.15	+0.23	+0.31	+0.39	+0.48	+0.57	+0.67	+0.77	+0.87
13	0	+0.06	+0.09	+0.16	+0.21	+0.26	+0.33	+0.37	+0.45	+0.49	+0.58
14	0	+0.08	+0.11	+0.19	+0.25	+0.31	+0.39	+0.44	+0.52	+0.57	+0.66
15	0	+0.06	+0.09	+0.13	+0.19	+0.24	+0.30	+0.34	+0.40	+0.45	+0.51
16	0	+0.04	+0.08	+0.12	+0.18	+0.22	+0.29	+0.32	+0.38	+0.41	+0.47
17	0	+0.01	+0.01	+0.02	+0.04	+0.05	+0.07	+0.07	+0.10	+0.10	+0.12
18	0	-0.01	+0.04	+0.06	+0.08	+0.10	+0.13	+0.14	+0.14	+0.17	+0.20
19	0	-0.01	-0.01	-0.01	-0.01	0	+0.01	-0.01	0	-0.01	0.01
20	0	+0.05	+0.10	+0.18	+0.25	+0.33	+0.44	+0.52	+0.63	+0.72	+0.84
21	0	-0.09	-0.16	-0.22	-0.28	-0.33	-0.41	-0.46	-0.52	-0.54	-0.59
22	0	+0.05	+0.11	+0.19	+0.25	+0.33	+0.43	+0.52	+0.63	+0.71	+0.82
23	0	-0.07	-0.14	-0.20	-0.25	-0.30	-0.35	-0.41	-0.46	-0.49	-0.53
24	0	+0.05	+0.11	+0.20	+0.26	+0.34	+0.44	+0.52	+0.62	+0.71	+0.81
25	0	-0.08	-0.15	-0.21	-0.26	-0.31	-0.35	-0.43	-0.47	-0.51	-0.54
26	0	+0.08	+0.14	+0.23	+0.29	+0.37	+0.48	+0.55	+0.65	+0.74	+0.85
27	0	-0.05	-0.15	-0.20	-0.27	-0.33	-0.37	-0.43	-0.50	-0.54	-0.58
28	0	+0.08	+0.16	+0.22	+0.31	+0.39	+0.49	+0.59	+0.69	+0.80	+0.91
29	0	-0.07	-0.13	-0.21	-0.26	-0.32	-0.38	-0.43	-0.50	-0.53	-0.58
30	0	+0.08	+0.16	+0.23	+0.32	+0.39	+0.48	+0.59	+0.69	+0.79	+0.89
31	0	-0.08	-0.15	-0.21	-0.27	-0.34	-0.40	-0.45	-0.52	-0.56	-0.62
32	0	+0.01	+0.01	+0.01	+0.01	0	+0.01	+0.01	+0.02	+0.02	+0.02
33	0	+0.01	0	0	0	-0.01	-0.01	-0.01	-0.01	-0.03	-0.04
34	0	-0.01	-0.03	-0.04	-0.05	-0.07	-0.07	-0.10	-0.10	-0.12	-0.13
35	0	+0.02	+0.01	+0.02	+0.02	+0.04	+0.02	+0.03	+0.05	+0.06	+0.07

100%	80%	60%	40%	20%	0%
+2.13	+1.79	+1.42	+1.03	+0.63	+0.17
+2.05	+1.71	+1.36	+0.99	+0.61	+0.15
+1.97	+1.64	+1.30	+0.93	+0.55	+0.11
+1.81	+1.51	+1.19	+0.85	+0.51	+0.12
+1.47	+1.25	+0.99	+0.73	+0.44	+0.11
+1.41	+1.20	+0.96	+0.70	+0.42	+0.11
+1.24	+1.07	+0.85	+0.63	+0.37	+0.09
+1.25	+1.08	+0.85	+0.61	+0.36	+0.08
+0.89	+0.78	+0.62	+0.46	+0.29	+0.07
+1.01	+0.89	+0.70	+0.53	+0.33	+0.09
+0.86	+0.76	+0.61	+0.45	+0.29	+0.06
+0.87	+0.74	+0.58	+0.42	+0.28	+0.05
+0.58	+0.47	+0.38	+0.29	+0.19	+0.05
+0.66	+0.57	+0.45	+0.35	+0.23	+0.08
+0.51	+0.44	+0.36	+0.27	+0.17	+0.06
+0.47	+0.42	+0.33	+0.25	+0.15	+0.03
+0.12	+0.10	+0.07	+0.07	+0.03	+0.02
+0.20	+0.18	+0.15	+0.12	+0.08	+0.03
0.01	-0.02	-0.02	-0.01	-0.02	-0.02
+0.84	+0.68	+0.52	+0.36	+0.20	+0.04
-0.59	-0.53	-0.47	-0.36	-0.24	-0.09
+0.82	+0.67	+0.51	+0.36	+0.21	+0.05
-0.53	-0.50	-0.42	-0.32	-0.21	-0.08
+0.81	+0.67	+0.50	+0.36	+0.20	+0.04
-0.54	-0.51	-0.44	-0.33	-0.22	-0.08
+0.85	+0.70	+0.54	+0.38	+0.24	+0.09
-0.58	-0.54	-0.46	-0.36	-0.23	-0.09
+0.91	+0.74	+0.56	+0.40	+0.23	+0.05
-0.58	-0.54	-0.46	-0.36	-0.26	-0.09
+0.89	+0.74	+0.56	+0.39	+0.23	+0.05
-0.62	-0.56	-0.46	-0.36	-0.23	-0.08
+0.02	+0.02	+0.02	+0.02	+0.02	+0.01
-0.04	-0.05	-0.06	-0.06	-0.05	-0.04
-0.13	-0.14	-0.12	-0.10	-0.07	-0.03
+0.07	+0.07	+0.06	+0.06	+0.04	+0.02

TABLE C-2

XFV-12A WING BOX - STATIC TEST TO DESIGN ULTIMATE

Ch. #	GAGE #	CORRECT REAL	INITIAL ZERO	INITIAL REAL	20% ↑	40% ↑	60% ↑	80% ↑	100% ↑	110% ↑	12
000	$1AU_o$	-2319	+7	-2322	-437	-893	-1362	-1848	-2327	-2553	-27
001	$1BU_o$	-2322	-339	-2320	-238	-20	-24	-289	-48	-47	-4
002	$1CU_o$	-2320	0	-2325	+271	+536	+800	+1069	+1337	+1460	+15
003	$1AU_i$	-2304	-3	-2313	-371	-749	-1136	-1530	-1917	-2097	-22
004	$1BU_i$	-2280	-4	-2283	+8	+32	+68	+111	+163	+193	+22
005	$1CU_i$	-2321	+2	-2322	+223	+455	+692	+932	+1173	+1283	+13
006	$2AU_o$	-2287	-6	-2294	-482	-965	-1455	-1947	-2433	-2671	-29
007	$2BU_o$	-2297	0	-2305	-35	-67	-96	-123	-145	-148	-14
008	$2CU_o$	-2304	0	-2305	+349	+699	+1046	+1402	+1757	+1931	+20
009	$3AU_o$	-2302	-6	-2296	-305	-601	-895	-1187	-1468	-1604	-178
010	$3BU_o$	-2300	-6	-2312	-55	-102	-144	-187	-225	-240	-25
011	$3CU_o$	-2270	-6	-2281	+121	+247	+374	+500	+623	+680	+73
012	$4AU_o$	-2296	-2	-2302	-422	-2309	-2663	-1681	-559	-2337	-167
013	$4BU_o$	-2316	-244	-2328	+5	-271	+4	-431	-146	-688	-309
014	$5AU_o$	-2299	+3	-2308	-264	-519	-762	-1004	-1234	-1343	-146
015	$4CU_o$	GAGE OUT	-	-	-	-	-	-	-	-	-
016	$5BU_o$	GAGE OUT	-	-	-	-	-	-	-	-	-
017	$5CU_o$	-2303	+6	-2318	+85	+123	+146	+183	+223	+219	+218
018	$5AU_i$	-2296	-2	-2307	-191	-368	-533	-696	-847	-912	-961
019	$5BU_i$	-2298	+5	-2300	-23	-41	-41	-28	-13	-8	-11
020	$5CU_i$	-2301	-3	-2313	+54	+108	+151	+190	+224	+242	+279
021	$6AU_o$	-2311	+6	-2306	-394	-791	-1185	-1580	-1968	-2146	-231
022	$6BU_o$	-2301	+14	-2293	+22	+34	+60	+91	+126	+145	+157
023	$6CU_o$	-2303	+8	-2306	+227	+434	+631	+821	+1010	+1096	+1171
024	$7AU_o$	-2303	+2	-2316	-428	-860	-1295	-1741	-2181	-2392	-259
025	$7BU_o$	-2360	-6	-2316	-9	-011	-10	-12	-18	-20	-24
026	$7CU_o$	-2300	-2	-2311	+261	+516	+763	+1007	+1248	+1360	+146
027	$8AU_o$	-2295	-1	-2301	-281	-562	-843	-1127	-1405	-1538	-166
028	$8BU_o$	-2302	+3	-2294	+9	+18	+30	+45	+62	+72	+83
029	$8CU_o$	-2308	-8	-2315	+170	+348	+525	+704	+883	+969	+105
030	$9AU_o$	-2302	+1	-2309	-413	-809	-1188	-1563	-1930	-2105	-227
031	$9BU_o$	-2301	-3	-2309	-39	-74	-108	-144	-174	-188	-200
032	$9CU_o$	-2306	-2	-2312	+190	+362	+511	+649	+780	+842	+909
033	$10AU_o$	-2302	-8	-2316	-387	-758	-1124	-1490	-1845	-2013	-217
034	$10BU_o$	-2303	0	-2311	-91	-176	-255	-331	-401	-429	-459
035	$10CU_o$	-2299	-5	-2311	+198	+390	+572	+749	+926	+1010	+1095
036	$11AU_o$	-2290	-1	-2301	-378	-747	-1107	-1467	-1823	-1993	-2165
037	$11BU_o$	-2300	0	-2305	-62	-132	-208	-290	-378	-419	-464
038	$11CU_o$	-2304	+3	-2306	+120	+231	+330	+424	+511	+550	+565
039	$12AU_o$	-2300	+2	-2309	-215	-429	-635	-845	-1059	-1162	-1262
040	$12BU_o$	-2293	-6	-2316	-152	-292	-425	-550	-678	-741	-800
041	$12CU_o$	-2293	-6	-2308	+107	+217	+324	+427	+533	+583	+632
042	$21U_o$	GAGE OUT	-	-	-	-	-	-	-	-	-
043	$22U_o$	-2199	+8	-2196	-35	-81	-114	-140	-168	-180	-196
044	$18U_o$	-2211	-1	-2223	-216	-452	-698	-945	-1179	-1288	-140
045	* $19U_o$	-2209	+4	-2213	-263	-547	-847	-1145	-1412	-1530	-162
046	$19U_i$	-2206	+3	-2211	-102	-206	-307	-387	-467	-511	-55
047	$20U_o$ Δ	-2216	+2	-2221	-397	-798	-1205	-1611	-2009	-2200	-238
048	$20U_i$	-2220	0	-2225	-294	-590	-891	-1193	-1491	-1634	-177
049	BLANK	-	-	-	-	-	-	-	-	-	-
050	13AS	-2325	+2	-2331	-200	-389	-584	-786	-983	-1069	-1153
051	13BS	-2316	-3	-2323	-71	-129	-197	-275	-352	-393	-430
052	13CS	GAGE OUT	-	-	-	-	-	-	-	-	-
053	14AS	-2317	-5	-2324	-193	-366	-545	-743	-919	-999	-1079

* U_o denotes upper cap outer surface
U_i denotes upper cap inner surface

Δ located on upper cover outer su

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#143

MATE LOAD – 9 AUGUST 1978 – RAW DATA

120%↑	130%↑	140%↑	150%	140%↓	120%↓	100%↓	80%↓	60%↓	40%↓	20%↓	FINAL ZERO
-2763	-2987	-3204	-3416	-3240	-2836	-2396	-1936	-1458	-979	-563	-32
-43	-45	-46	-51	-60	-71	-71	-73	-67	-52	-36	-2
+1563	+1690	+1809	+1925	+1835	+1622	+1387	+1136	+870	+589	+302	+9
-2263	-2446	-2621	-2794	-2649	-2317	-1960	-1582	-1189	-794	-402	-12
+227	+261	+295	+327	+288	+219	+157	+104	+56	+22	+2	+3
+1383	+1499	+1609	+1717	+1634	+1434	+1215	+982	+738	+488	+236	-15
-2904	-3142	-3379	-3613	-3408	-2961	-2493	-2009	-1514	-1021	-530	-43
-149	-153	-153	-150	-162	-169	-164	-148	-126	-96	-59	-11
+2097	+2275	+2454	+2622	+2485	+2179	+1851	+1510	+1156	+796	+429	+54
-1733	-1864	-1977	-2111	-1997	-297	-2675	-306	-915	-618	-316	-18
-254	-267	-280	-292	-282	-255	-224	-186	-144	-101	-56	-10
+733	+785	+835	+885	+839	+736	+625	+509	+385	+257	+125	-18
-167	-164	-2963	-3182	-1916	-2586	-2169	-1741	-216	-350	-457	-25
-309	+6	-6	-356	-586	-1	+6	-6	+30	+14	-1454	-285
-1466	-1563	-1664	-1758	-1684	-1498	-1292	-1070	-836	-588	-324	-38
–	–	–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–
+218	+227	+407	+222	+220	+208	+194	+176	+152	+104	+25	-93
-961	-1030	-1089	-1151	-1097	-967	-824	-670	-508	-334	-148	+29
-11	-8	-8	-5	-10	-17	-24	-28	-36	-43	-37	-10
+279	+298	+318	+332	+330	+313	+292	+266	+233	+190	+128	+38
-2310	-2481	-2649	-2811	-2678	-2364	-2019	-1648	-1259	-854	-440	-12
+157	+178	+197	+222	+194	+144	+100	+63	+29	+2	-14	-7
+1171	+1254	+1338	+1420	+1361	+1218	+1058	+884	+696	+489	+261	+6
-2596	-2808	-3019	-3225	-3053	-2666	-2255	-1827	-1389	-946	-497	-36
-24	-30	-39	-46	-45	-39	-35	-31	-30	-28	-26	-18
+1466	+1580	+1690	+1795	+1716	+1530	+1322	+1098	+857	+602	+327	+24
-1666	-1797	-1927	-2055	-1943	-1694	-1433	-1162	-885	-609	-330	-41
+83	+93	+104	+114	+107	+93	+77	+64	+50	+37	+25	+12
+1050	+1134	+1219	+1301	+1233	+1081	+919	+750	+575	+394	+205	+2
-2275	-2440	-2605	-2767	-2637	-2329	-1993	-1634	-1263	-878	-471	-26
-200	-213	-224	-234	-227	-205	-175	-140	-105	-73	-44	-11
+909	+967	+1028	+1083	+1048	+956	+848	+723	+588	+438	+254	+20
-2176	-2338	-2498	-2653	-2526	-2227	-1902	-1557	-1197	-827	-442	-32
-459	-484	-507	-530	-512	-461	-403	-333	-260	-182	-101	-9
+1095	+1179	+1260	+1341	+1284	+1144	+990	+825	+650	+465	+259	+16
-2165	-2327	-2490	-2651	-2522	-2221	-1895	-1550	-1198	-841	-462	-40
-464	-504	-547	-590	-557	-480	-400	-314	-232	-154	-86	-16
+565	+635	+671	+701	+684	+634	+572	+498	+415	+320	+198	+34
-1262	-1363	-1462	-1557	-1489	-1318	-1123	-912	-697	-480	-256	-30
-800	-861	-920	-981	-931	-813	-683	-542	-399	-261	-130	-12
+632	+681	+729	+776	+741	+654	+557	+450	+339	+227	+113	0
–	–	–	–	–	–	–	–	–	–	–	–
-196	-204	-211	-218	-215	-204	-188	-167	-143	-109	-64	-7
-1408	-1500	-1594	-1686	-1601	-1402	-1186	-954	-715	-477	-249	-30
-1625	-1709	-1809	-1919	-1811	-1561	-1289	-1000	-703	-419	-164	+58
-559	-593	-635	-681	-629	-518	-405	-294	-190	-103	-38	+16
-2386	-2566	-2745	-2924	-2751	-2379	-1992	-1591	-1182	-775	-375	+16
-1778	-1905	-2040	-2174	-2044	-1763	-1471	-1170	-864	-562	-265	+24
–	–	–	–	–	–	–	–	–	–	–	–
-1153	-1224	-1295	-1371	-1310	-1146	-963	-766	-563	-360	-165	+18
-430	-467	-502	-540	-509	-436	-359	-277	-196	-123	-55	-6
–	–	–	–	–	–	–	–	–	–	–	–
-1079	-1146	-1215	-1286	-1228	-1067	-904	-720	-531	-343	-162	+7

ter surface

TABLE C-2 (Cont'd.)

XFV-12A WING BOX – STATIC TEST TO DESIGN ULTIMATE LOAD –

Ch. #	GAGE #	CORRECT RCAL	INITIAL ZERO	INITIAL RCAL	20% ↑	40% ↑	60% ↑	80% ↑	100% ↑	110% ↑
054	14BS	-2322	-2	-2309	-69	-130	-263	-291	-378	-421
055	14CS	-2314	-4	-2326	+154	+311	+466	+618	+758	+816
056	15AS	-2302	+4	-2304	+56	+106	+154	+207	+265	+291
057	15BS	-2308	-1	-2318	-20	-32	-37	-32	-27	-27
058	15CS	-2312	-1	-2314	-21	-38	-53	-68	-92	-105
059	16AS	-2322	+4	-2323	-8	-32	-63	-99	-130	-134
060	16BS	-2316	+3	-2322	+23	+43	+62	+81	+100	+108
061	16CS	-2321	0	-2381	-18	-25	-27	-22	-26	-40
062	17AS	-2319	+3	-2322	-53	-111	-164	-219	-280	-308
063	17BS	-2308	+4	-2311	+31	+62	+98	+136	+172	+190
064	17CS	-2304	+7	-2307	+15	+27	+37	+35	+28	+16
65-99	BLANK	–	–	–	–	–	–	–	–	–
100	1AL$_o$	-2376	0	-2394	+399	+815	+1238	+1668	+2080	+2282
101	1BL$_o$	-2369	-3	-2381	-26	-50	-79	-110	-145	-170
102	1AL$_i$	-2366	-1	-2375	+357	+731	+1112	+1501	+1875	+2049
103	1CL$_o$	GAGE OUT	–	–	–	–	–	–	–	–
104	1BL$_i$	-2376	+3	-2386	-29	-62	-96	-130	-159	-179
105	1CL$_i$	-2364	-1	-2375	-232	-477	-727	-982	-1220	-1330
106	2AL$_o$	-2364	-3	-2364	+421	+849	+1279	+1718	+2145	+2350
107	2BL$_o$	-2364	-5	-2331	-6	-4	-5	-5	-12	-21
108	2CL$_o$	-2375	-2	-2384	-309	-620	-939	-1271	-1604	-1765
109	3AL$_o$	-2375	+9	-2380	+309	+616	+920	+1229	+1528	+1675
110	3BL$_o$	-2374	-1	-2377	+29	+54	+76	+100	+120	+128
111	3CL$_o$	-2383	-6	-2392	-173	-362	-556	-754	-950	-1043
112	4AL$_o$	-2375	-7	-2395	+327	+671	+1021	+1377	+1721	+1888
113	4BL$_o$	-2368	-4	-2388	+54	+118	+167	+204	+228	+235
114	4CL$_o$	-2370	-4	-2380	-140	-290	-445	-611	-779	-836
115	5AL$_o$	-2363	+1	-2355	+223	+437	+653	+875	+1089	+1183
116	5BL$_o$	-2360	-4	-2372	+19	+36	+50	+77	+110	+122
117	5CL$_o$	-2373	+3	-2381	-4	-19	-35	-49	-56	-59
118	5AL$_i$	-2378	+1	-2383	+194	+398	+602	+802	+987	+1069
119	5BL$_i$	-2389	-2	-2383	-44	-81	-124	-172	-214	-233
120	5CL$_i$	-2370	+3	-2380	-49	-89	-129	-173	-208	-221
121	6AL$_o$	-2361	-4	-2372	+373	+750	+1129	+1511	+1878	+2047
122	6BL$_o$	-2364	-8	-2380	-3	-6	-16	-29	-43	-53
123	6CL$_o$	-2369	-2	-2380	-170	-341	-519	-704	-880	-964
124	7AL$_o$	GAGE OUT	–	–	–	–	–	–	–	–
125	7BL$_o$	-2375	+5	-2386	+34	+60	+79	+93	+105	+107
126	7CL$_o$	-2374	-3	-2377	-269	-541	-818	-1103	-1385	-1521
127	8AL$_o$	-2648	-3	-2704	+176	+357	+536	+716	+889	+971
128	8BL$_o$	-2358	0	-2365	-35	-69	-107	-148	-198	-225
129	8CL$_o$	-2342	-4	-2358	-196	-390	-585	-782	-977	-1072
130	9AL$_o$	-2336	-3	-2344	+337	+670	+996	+1320	+1635	+1777
131	9BL$_o$	-2329	+2	-2348	+16	+30	+40	+51	+65	+69
132	9CL$_o$	-2353	-5	-2365	-146	-278	-404	-529	-650	-704
133	10AL$_o$	-2343	-3	-2353	+353	+705	+1051	+1398	+1732	+1887
134	10BL$_o$	-2338	-6	-2356	+60	+120	+174	+228	+278	+299
135	10CL$_o$	-2344	-3	-2356	-192	-374	-550	-727	-900	-980
136	BLANK — SEE Ch. #149 FOR GAGE # 11AL$_o$					–	–	–	–	–
137	11BL$_o$	GAGE OUT	–	–	–	–	–	–	–	–
138	11CL$_o$	GAGE OUT	–	–	–	–	–	–	–	–
139	12AL$_o$	GAGE OUT	–	–	–	–	–	–	–	–
140	12BL$_o$	-2338	-5	-2347	+168	+322	+460	+583	+705	+759
141	12CL$_o$	-2334	0	-2344	-206	-407	-597	-780	-960	-1049

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#273

120%↑	130%↑	140%↑	150%	140%↓	120%↓	100%↓	80%↓	60%↓	40%↓	20%↓	FINAL ZERO
-462	-501	-541	-581	-551	-477	-398	-314	-231	-150	-76	-12
+871	+918	+965	+1016	+977	+871	-746	+605	+452	+294	+134	-31
+323	+351	+375	+396	+389	+363	+327	+290	+252	+203	+134	+39
-28	-31	-38	-40	-38	-34	-32	-33	-34	-35	-31	-15
-120	-135	-146	-154	-158	-158	-150	-140	-129	-113	-86	-35
-136	-137	-137	-139	-156	-160	-147	-121	-86	-53	-27	-10
+115	+121	+126	+131	+127	+115	+101	+84	+64	+45	+26	+9
-55	-74	-94	-112	-79	-41	-17	-10	-9	-9	-3	+10
-338	-370	-408	-450	-423	-357	-293	-230	-168	-108	-52	+2
+205	+219	+230	+242	+230	+203	+171	+136	+98	+63	+32	+5
+3	-14	-32	-45	-17	+19	+42	+48	+45	+35	+21	+8
—	—	—	—	—	—	—	—	—	—	—	—
+2457	+2642	+2824	+3003	+2855	+2510	+2134	+1734	+1310	+881	+451	+25
-192	-217	-245	-273	-239	-182	-133	-94	-61	-35	-19	-13
+2219	+2388	+2557	+2723	+2587	+2271	+1929	+1564	+1181	+793	+403	+20
—	—	—	—	—	—	—	—	—	—	—	—
-194	-213	-231	-249	-230	-194	-161	-133	-105	-74	-45	-17
-1435	-1544	-1648	-1745	-1673	-1494	-1296	-1077	-835	-581	-316	-50
+2550	+2753	+2955	+3152	+2984	+2610	+2210	+1791	+1356	+917	+475	+29
-30	-35	-40	-46	-27	-4	+13	+20	+22	+20	+11	-3
-1921	-3079	-2237	-2389	-2262	-1978	-1674	-1357	-1030	-701	-372	-46
+1819	+1962	+2105	+2247	+2117	+1838	+1548	+1249	+940	+629	+315	+3
+135	+139	+142	+148	+142	+127	+110	+88	+65	+44	+17	-18
-1134	-1228	-1323	-1414	-1339	-1171	-993	-804	-610	-412	-218	-37
+2052	+2215	+2379	+2538	+2389	+2071	+1741	+1400	+1050	+696	+342	-3
+242	+247	+251	+256	+248	+224	+202	+175	+142	+98	+36	-26
-947	-1035	-1124	-1213	-1142	-991	-834	-674	-507	-346	-188	-28
+1274	+1359	+1444	+1528	+1457	+1287	+1102	+900	+683	+459	+226	-12
+136	+148	+159	+170	+170	+165	+154	+137	+122	+97	+59	+8
-60	-58	-61	-65	-59	-45	-33	-23	-9	+4	+20	+39
+1147	+1220	+1292	+1374	+1308	+1151	+978	+790	+591	+388	+182	-28
-249	-267	-285	-302	-285	-249	-212	-175	-126	-74	-28	+7
-228	-237	-247	-258	-255	-244	-230	-208	-173	-126	-66	+5
+2212	+2373	+2633	+2691	+2557	+2251	+1916	+1557	+1178	+791	+396	+3
-62	-72	-82	-92	-77	-55	-36	-25	-14	-6	-7	-17
-1044	-1126	-1207	-1289	-1225	-1081	-927	-759	-580	-398	-210	-21
—	—	—	—	—	—	—	—	—	—	—	—
+109	+113	+117	+120	+124	+123	+119	+105	+88	+65	+36	-5
-1651	-1781	-1909	-2035	-1932	-1702	-1453	-1189	-911	-629	-340	-50
+1051	+1129	+1208	+1285	+1215	+1064	+901	+728	+549	+366	+181	-7
-252	-281	-309	-337	-313	-268	-221	-179	-189	-101	-68	-36
-1163	-1255	-1345	-1433	-1361	-1201	-1029	-844	-651	-455	-252	-45
+1917	+2050	+2183	+2313	+2202	+1942	+1655	+1343	+1019	+686	+339	-21
+76	+82	+88	+93	+95	+90	+80	+66	+53	+41	+28	+11
-756	-804	-853	-903	-866	-778	-677	-563	-443	-316	-170	-7
+2039	+2185	+2331	+2473	+2350	+2069	+1760	+1429	+1085	+732	+368	-6
+321	+340	+362	+381	+368	+329	+283	+230	+179	+117	+57	-12
-1057	-1130	-1202	-1274	-1218	-1080	-931	-767	-595	-416	-223	-17
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
+817	+874	+928	+989	+949	+818	+694	+562	+426	+297	+161	+4
-1136	-1222	-1307	-1395	-1330	-1179	-1012	-838	-656	-468	-266	-36

XFV-12A WING BOX - STATIC TEST TO DESIGN ULTIMATE

Ch #	GAGE #	CORRECT REAL	INITIAL ZERO	INITIAL REAL	20% ↑	40% ↑	60% ↑	80% ↑	100% ↑	110% ↑	120
142	$21L_o$	-2256	-2	-2261	-12	-22	-30	-34	-35	-37	-39
143	$22L_o$	-2250	+2	-2257	+5	+9	+14	+19	+23	+26	+28
144	$18L_o$	-2224	+4	-2230	+316	+652	+990	+1339	+1655	+1789	-1917
145 *	$19L_o$	-2229	+4	-2228	+335	+680	+1000	+1302	+1605	+1746	+188
146	$19L_i$	-2243	+7	-2248	+100	+183	+277	+382	+503	+565	+62
147	$20L_o$ Δ	-2238	+1	-2245	+389	+781	+1179	+1586	+1988	+2183	+238
148	$20L_i$	-2238	+2	-2257	+247	+491	+738	+988	+1233	+1350	+146
149	$11AL_o$	-2316	-8	-2339	+295	+589	+871	+1151	+1426	+1552	+167
150-159	BLANK	–	–	–	–	–	–	–	–	–	–

* L_o denotes lower cap outer surface
L_i denotes lower cap inner surface
Δ located on lower cover outer surface

DEFLECTION READINGS — DIRECTLY IN INCHES

Ch #	X-DUCER #	XDUCER RANGE	INITIAL ZERO	–	20%	40%	60%	80%	100%	110%	120%
160	D-1		+.03	–	+.46	+.84	+1.28	+1.63	+2.09	+2.22	+2.40
161	D-2		+.04	–	+.43	+.80	+1.20	+1.57	+2.01	+2.13	+2.30
162	D-3		+.02	–	+.40	+.78	+1.16	+1.52	+1.92	+2.07	+2.24
163	D-4		+.02	–	+.39	+.72	+1.08	+1.41	+1.75	+1.95	+2.10
164	D-5		+.01	–	+.31	+.58	+0.88	+1.15	+1.47	+1.55	+1.68
165	D-6		+.02	–	+.31	+.58	+0.82	+1.11	+1.38	+1.49	+1.61
166	D-7		+.01	–	+.26	+.51	+0.74	+0.99	+1.23	+1.33	+1.44
167	D-8		+.07	–	+.26	+.50	+0.74	+0.99	+1.21	+1.34	+1.44
168	D-9		+.02	–	+.19	+.37	+0.52	+0.70	+0.88	+0.97	+1.04
169	D-10		+.04	–	+.21	+.40	+0.59	+0.79	+0.98	+1.06	+1.14
170	D-11		+.03	–	+.18	+.35	+0.51	+0.68	+0.84	+0.90	+0.97
171	D-12		+.04	–	+.17	+.33	+0.51	+0.66	+0.83	+0.90	+0.97
172	D-13		+.04	–	+.12	+.22	+0.33	+0.43	+0.53	+0.57	+0.61
173	D-14		+.05	–	+.15	+.26	+0.41	+0.49	+0.61	+0.66	+0.75
174	D-15		+.01	–	+.12	+.21	+0.31	+0.40	+0.50	+0.53	+0.56
175	D-16		+.04	–	+.11	+.19	+0.29	+0.37	+0.44	+0.50	+0.53
176	D-17		+.03	–	+.05	+.05	+0.08	+0.11	+0.10	+0.13	+0.13
177	D-18		+.03	–	+.08	+.10	+0.11	+0.17	+0.21	+0.21	+0.22
178	D-19		+.01	–	+.03	+.01	+0.01	+0.02	+0.02	+0.01	+0.00
179	D-20		+.01	–	+.15	+.29	+0.44	+0.63	+0.77	+0.92	+1.01
180	D-21		+.03	–	-.11	-.22	-0.29	-0.43	-0.51	-0.53	-0.55
181	D-22		+.00	–	+.14	+.29	+0.47	+0.63	+0.82	+0.92	+1.00
182	D-23		+.09	–	-.10	-.22	-0.31	-0.41	-0.48	-0.51	-0.56
183	D-24		+.04	–	+.15	+.29	+0.46	+0.63	+0.81	+0.91	+0.99
184	D-25		+.06	–	-.09	-.21	-0.31	-0.41	-0.48	-0.52	-0.55
185	D-26		+.04	–	+.16	+.31	+0.47	+0.65	+0.80	+0.92	+1.02
186	D-27		+.04	–	-.10	-.23	-0.36	-0.43	-0.52	-0.54	-0.59
187	D-28		+.05	–	+.18	+.33	+0.49	+0.69	+0.90	+0.99	+1.09
188	D-29		+.06	–	-.08	-.22	-0.35	-0.41	-0.47	-0.53	-0.56
189	D-30		-.02	–	+.19	+.33	+0.49	+0.69	+0.84	+0.97	+1.07
190	D-31		+.02	–	-.08	-.23	-0.36	-0.45	-0.54	-0.57	-0.61
191	D-32		+.01	–	+.04	+.02	+0.03	+0.03	+0.03	+0.05	+0.05
192	D-33		+.01	–	+.04	+.02	+0.02	-0.01	-0.02	-0.02	-0.03
193	D-34		+.02	–	-.01	-.02	-0.04	-0.07	-0.09	-0.10	-0.11
194	D-35		+.02	–	+.03	+.04	+0.04	+0.06	+0.10	+0.08	+0.07
195-199	BLANK	–	–	–	–	–	–	–	–	–	–

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THIS PAGE IS BEST QUALITY PRACTICABLE
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#3 of 3

(Concluded)

ATE LOAD - 9 AUGUST 1978 - RAW DATA

↑	120% ↑	130% ↑	140% ↑	150%	140% ↓	120% ↓	100% ↓	80% ↓	60% ↓	40% ↓	20% ↓	FINAL ZERO
	-39	-44	-50	-55	-51	-45	-41	-40	-37	-33	-22	-9
	+28	+31	+33	+35	+36	+36	+33	+27	+21	+19	+19	+10
	-1917	+2038	+2163	+2288	+2173	+1890	+1580	+1253	+918	+588	+277	-15
	+1883	+2009	-2135	+2258	+2142	+1864	+1564	+1251	+932	+626	+338	+53
	+625	+686	+744	+799	+752	+653	+550	+446	+337	+232	+134	+39
	+2380	+2597	+2826	+3042	+2883	+2523	+2142	+1748	+1339	+930	+523	+117
	+1463	+1572	+1681	+1788	+1683	+1460	+1224	+982	+732	+484	+237	-6
	+1678	+1800	+1918	+2034	+1939	+1716	+1469	+1196	+916	+630	+328	+4
	—	—	—	—	—	—	—	—	—	—	—	—

	120%	130%	140%	150%	140%	120%	100%	80%	60%	40%	20%	FINAL ZERO
	+2.40	+2.59	+2.77	+2.94	+2.82	+2.53	+2.18	+1.79	+1.43	+1.02	+0.60	+0.12
	+2.30	+2.47	+2.64	+2.80	+2.68	+2.38	+2.06	+1.70	+1.36	+0.97	+0.56	+0.11
	+2.24	+2.40	+2.57	+2.73	+2.62	+2.32	+2.01	+1.66	+1.31	+0.93	+0.53	+0.09
	+2.10	+2.25	+2.40	+2.54	+2.46	+2.17	+1.89	+1.57	+1.25	+0.91	+0.55	+0.14
	+1.68	+1.81	+1.89	+2.05	+1.96	+1.74	+1.53	+1.28	+1.00	+0.73	+0.42	+0.08
	+1.61	+1.73	+1.83	+1.95	+1.88	+1.72	+1.46	+1.23	+0.96	+0.71	+0.41	+0.08
	+1.44	+1.54	+1.64	+1.75	+1.70	+1.53	+1.34	+1.10	+0.87	+0.64	+0.38	+0.08
	+1.44	+1.54	+1.64	+1.74	+1.69	+1.52	+1.34	+1.14	+0.88	+0.63	+0.36	+0.06
	+1.04	+1.11	+1.17	+1.25	+1.21	+1.11	+0.99	+0.80	+0.66	+0.48	+0.27	+0.07
	+1.14	+1.22	+1.34	+1.38	+1.35	+1.22	+1.07	+0.88	+0.73	+0.52	+0.31	+0.07
	+0.97	+1.04	+1.10	+1.16	+1.15	+1.03	+0.91	+0.76	+0.62	+0.44	+0.26	+0.06
	+0.97	+1.04	+1.12	+1.17	+1.14	+1.03	+0.90	+0.74	+0.58	+0.41	+0.24	+0.04
	+0.61	+0.65	+0.70	+0.73	+0.71	+0.63	+0.55	+0.47	+0.37	+0.27	+0.16	+0.03
	+0.75	+0.76	+0.81	+0.85	+0.82	+0.76	+0.66	+0.56	+0.44	+0.32	+0.19	+0.05
	+0.56	0.60	+0.63	+0.66	+0.65	+0.59	+0.62	+0.44	+0.35	+0.26	+0.16	+0.03
	+0.53	+0.56	+0.57	+0.58	+0.56	+0.59	+0.51	+0.43	+0.35	+0.25	+0.15	+0.03
	+0.13	+0.13	+0.14	+0.14	+0.12	+0.13	+0.10	+0.09	+0.08	+0.06	+0.03	0
	+0.22	+0.22	+0.22	+0.23	+0.21	+0.22	+0.18	+0.16	+0.13	+0.10	+0.06	+0.02
	+0.00	-0.01	-0.01	-0.02	-0.05	-0.02	-0.03	-0.03	-0.02	-0.02	-0.03	-0.01
	+1.01	+1.11	+1.21	+1.32	+1.26	+1.06	+0.90	+0.72	+0.54	+0.37	+0.19	+0.03
	-0.55	-0.59	-0.55	-0.63	-0.64	-0.60	-0.56	-0.50	-0.44	-0.32	-0.21	-0.04
	+1.00	+1.11	+1.22	+1.30	+1.24	+1.07	+0.88	+0.72	+0.53	+0.36	+0.19	+0.06
	-0.56	-0.57	-0.59	-0.61	-0.61	-0.59	-0.55	-0.47	-0.42	-0.32	-0.24	-0.07
	+0.99	+1.09	+1.20	+1.29	+1.24	+1.05	+0.87	+0.69	+0.52	+0.35	+0.17	+0.02
	-0.55	-0.58	-0.61	-0.63	-0.65	-0.57	-0.54	-0.49	-0.40	-0.32	-0.19	-0.05
	+1.02	+1.11	+1.19	+1.31	+1.24	+1.06	+0.90	+0.73	+0.55	+0.39	+0.22	+0.05
	-0.59	-0.62	-0.66	-0.67	-0.67	-0.64	-0.59	-0.51	-0.44	-0.34	-0.22	-0.06
	+1.09	+1.19	+1.30	+1.40	+1.31	+1.17	+0.96	+0.77	+0.59	+0.41	+0.21	+0.06
	-0.56	-0.60	-0.63	-0.65	-0.65	-0.63	-0.58	-0.51	-0.45	-0.33	-0.19	-0.06
	+1.07	+1.17	+1.26	+1.38	+1.31	+1.09	+0.94	+0.76	+0.57	+0.39	+0.21	+0.05
	-0.61	-0.65	-0.69	-0.70	-0.70	-0.67	-0.62	-0.53	-0.46	-0.34	-0.20	-0.04
	+0.05	+0.04	+0.06	+0.05	+0.04	+0.03	+0.03	+0.03	+0.03	+0.02	+0.02	0
	-0.03	-0.05	-0.04	-0.05	-0.04	-0.07	-0.07	-0.07	-0.08	-0.07	-0.05	-0.03
	-0.11	-0.13	-0.12	-0.15	-0.15	-0.17	-0.15	-0.12	-0.11	-0.08	-0.06	-0.01
	+0.07	+0.08	+0.11	+0.09	+0.07	+0.09	+0.07	+0.08	+0.07	+0.06	+0.05	+0.02
	—	—	—	—	—	—	—	—	—	—	—	—

2

Max. Vertical Landing Cond.

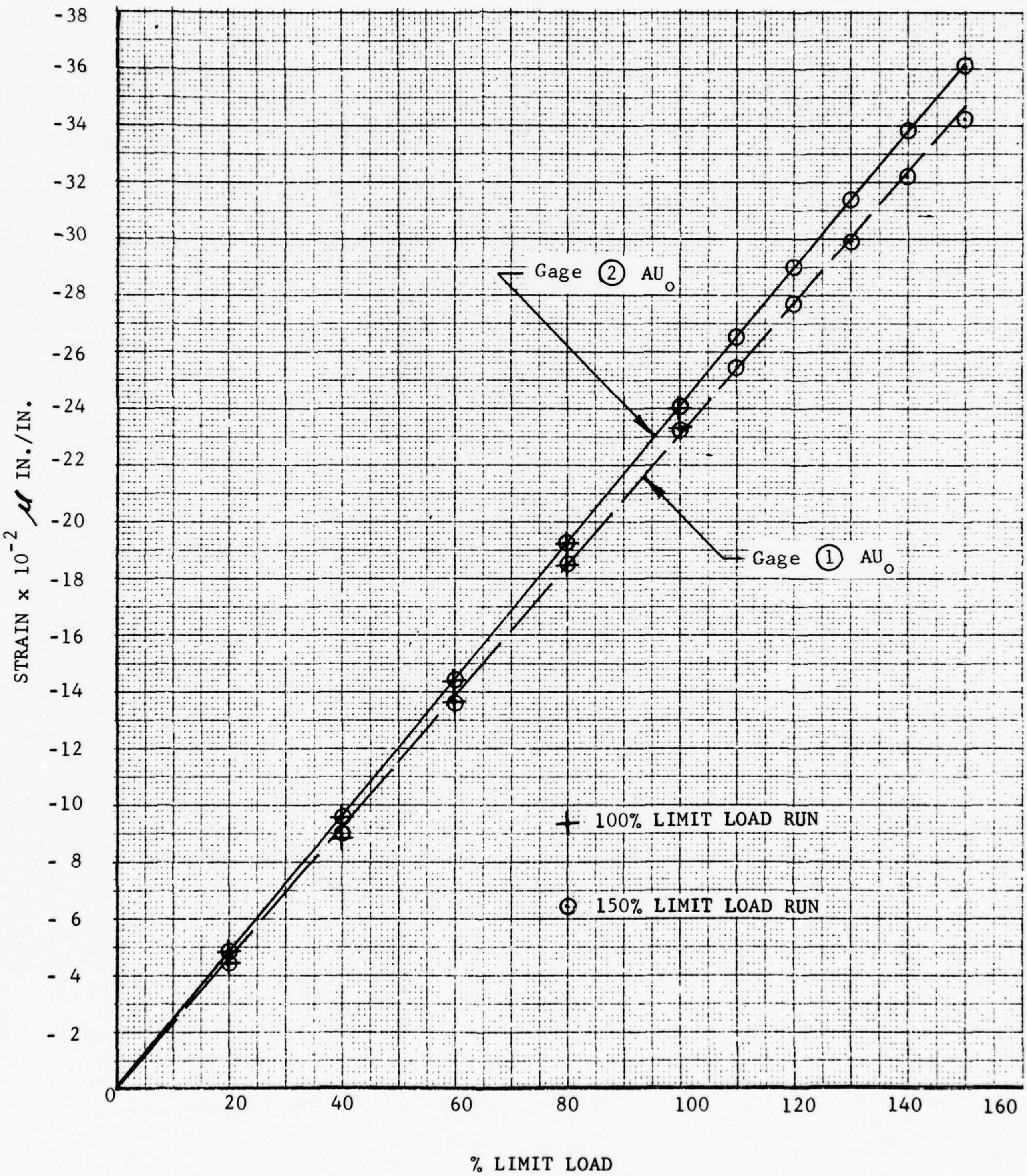

Figure C-21 Wing Box Upper Cover Rosette Gage Reading Vs. % Limit Load

REF. LOCATION ① Max. Vertical Landing Cond.

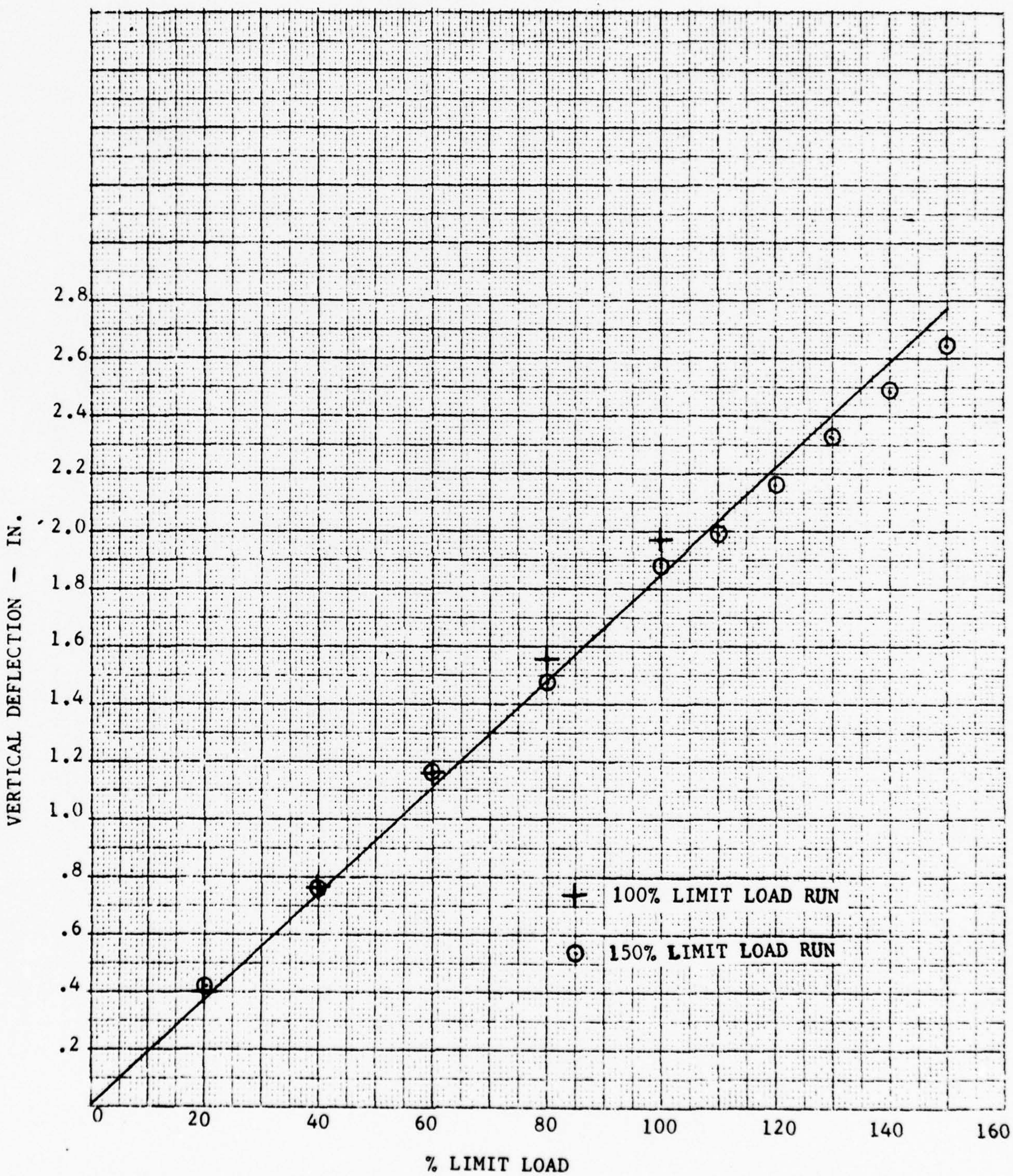

Figure C-22 Wing Box Vertical Deflection of Fwd Spar @ R.S. Sta 79.54

TABLE C-3

COMPARISON OF WING TEST BOX RECORDED STRAINS @ 100% LIMIT LOAD

Max vertical landing cond. 100% Lim. Ld. Run & 150% Lim. Ld. Run values

Wing Upper Cover Gages

Gage No.	Gage Type	ε_x*	ε_{xy}*	ε_y*
1_o	Rosette	-2334(-2327)	1322(1337)	Gage out
1_i		-1905(-1917)	1141(1173)	174(163)
2_o		-2425(-2433)	1756(1757)	-158(-145)
3_o		-1440$^\Delta$(-1468)	629(623)	-220(-225)
4_o		-2103(-2125)	Gage out	Gage out
5_o		-1140(-1234)	171(223)	Gage out
5_i		- 734(- 847)	286(224)	- 14(- 13)
6_o		-1958(-1968)	969(1010)	84(126)
7_o		-2174(-2181)	1258(1248)	- 17(- 18)
8_o		-1389(-1405)	896(883)	61(62)
9_o		-1939(-1930)	802(780)	-179(-174)
10_o		-1828(-1845)	947(926)	-402(-401)
11_o		-1841(-1823)	Gage out	-394(-378)
12_o	Rosette	Gage out	547	Gage out

Wing Lower Cover Gages

Gage No.	Gage Type	ε_x*	ε_{xy}*	ε_y*
1_o	Rosette	2066(2080)	Gage out	-126(-142)
1_i		1875(1876)	-1244(-1219)	-155(-162)
2_o		2134(2148)	-1586(-1602)	0(- 7)
3_o		1518(1524)	- 932(- 944)	123(121)
4_o		1728(1728)	- 770(- 775)	239(232)
5_o		1084(1088)	Gage out	145(114)
5_i		936(987)	- 199(211)	-210(-212)
6_o		1871(1882)	- 860(- 878)	- 19(-35)
7_o		Gage out	-1377(-1383)	104(100)
8_o		880(892)	- 972(- 973)	-196(-198)
9_o		1639(1638)	- 655(- 645)	86(63)
10_o		1740(1734)	- 898(- 897)	293(284)
11_o		1459(1434)	Gage out	Gage out
12_o	Rosette	Gage out	- 960(- 960)	682(710)

$^\Delta$Extrapolated value

* 150% limit load run values in parenthesis

o - outer skin
i - inner skin

TABLE C-3 (Concluded)

COMPARISON OF WING TEST BOX RECORDED STRAINS @ 100% LIMIT LOAD

Max. vertical landing cond. 100% Lim. Ld. Run & 150% Lim. Ld. run values

Wing Spar Gages

Gage No.	Gage Type	ε_x* in/in.	ε_{xy}* in./in.	ε_y* in/in.
13 aft int. spar	Rosette	-983(-983)	Gage Out	-329(-352)
14 aft int. spar	↕	-891(-918)	759(758)	-375(-378)
15 fwd spar		329(265)	-141(-92)	- 7(- 27)
16 rear spar		-141(-130)	- 18(-26)	98(100)
17 rear spar	Rosette	-287(-283)	Gage Out	165(168)

Wing Rear Spar Cap Gages

Gage No.	Gage Type	ε_x* in/in.
18 U_o^△	Axial	-1197(-1179)
18 L_o^□	↕	1633(1655)
19 U_o		-1296(-1412)
19 L_o		1534(1605)
20 U_o		-1977(-2009)
20 L_o	Axial	1976(1988)

* 150% limit load run values in parenthesis

△ U_o denotes upper cap outer surface

□ L_o denotes lower cap outer surface

Max. vertical landing cond. (max. oper. loads 150% D.L.L.)
Strains - μ in./in.

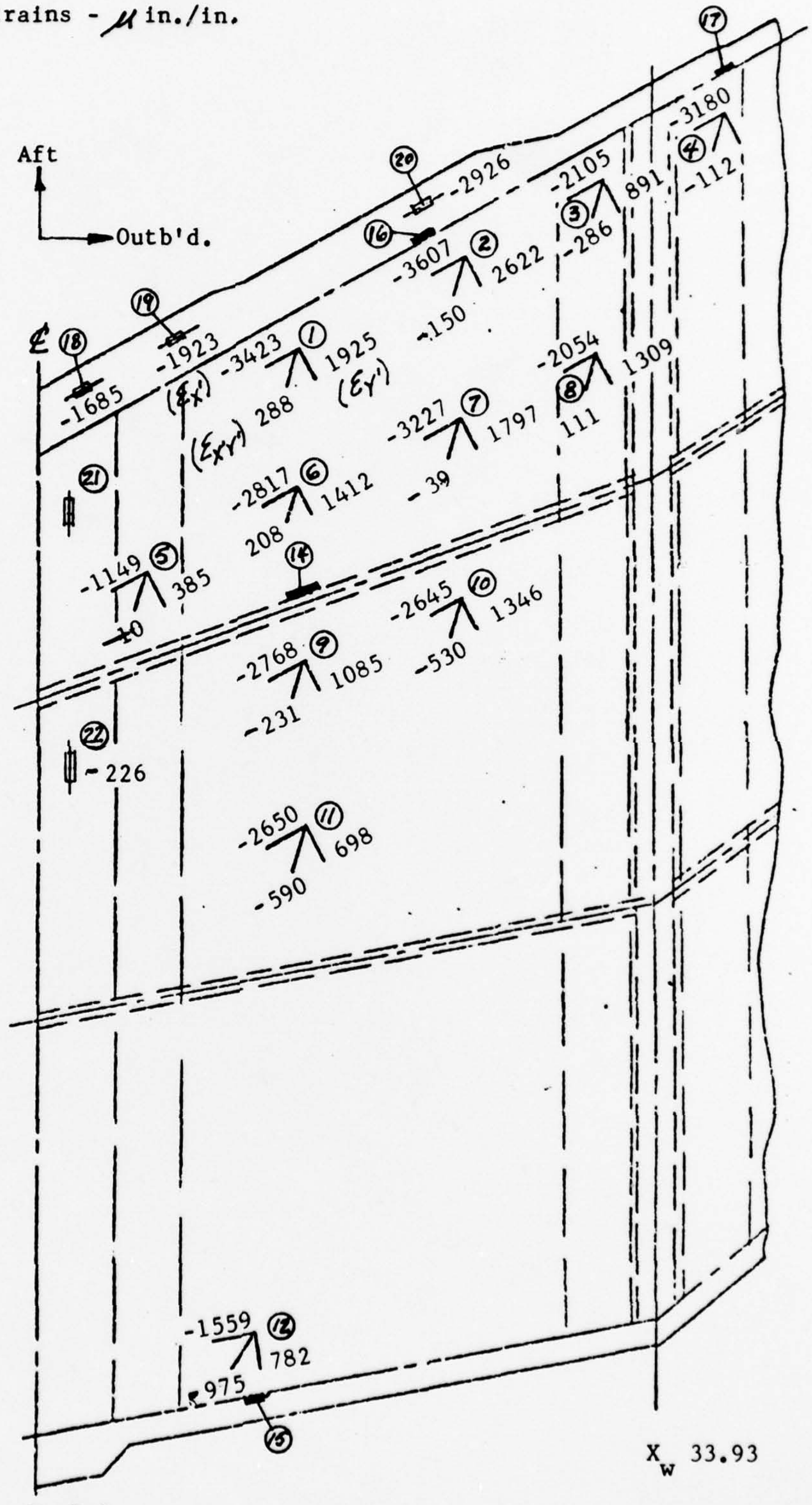

Figure C-23 Upper Cover and Rear Spar Cap Recorded Strains at 150% D.L.L.

Max. vertical landing cond. (max. oper. loads 150% D.L.L.)

Strains- μin./in.

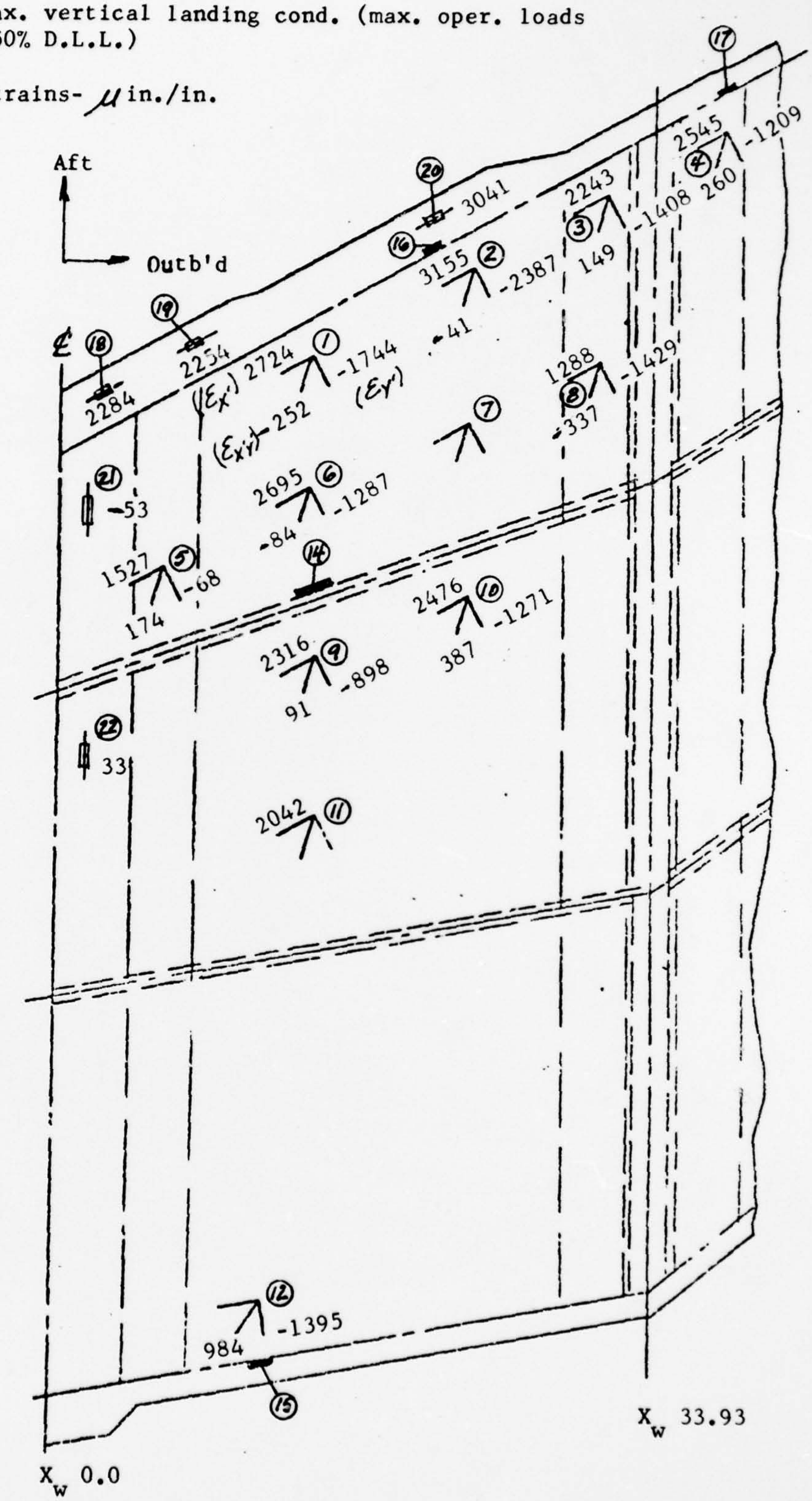

Figure C-24 Lower Cover and Rear Spar Cap Recorded Strains at 150% D.L.L.

C-5-2 Comparison of Predicted and Measured Strains

Comparisons of predicted and measured strains at the 150% D.L.L. level are presented in Table C-4. Predicted strain values are calculated from a NASTRAN stress analysis of the composite wing box test section which simulates the test setup restraint conditions as noted in Paragraph C-2. The basic NASTRAN model utilizes triangular CTRIA 1 sandwich plate elements which have their "X" axis oriented normal to the airplane center line in the inboard portions of the wing box as shown in Figures C-7 and C-8.

The wing cover rosette gages are located with the "A" legs parallel to the rear spar which is swept aft at a 28.35° angle with respect to an axis normal to the airplane center line as shown in Figure C-18. A 28.35° rotation of the NASTRAN stresses is required to calculate strains in the laminate parallel and perpendicular to the rear spar axis as shown in Figure C-25.

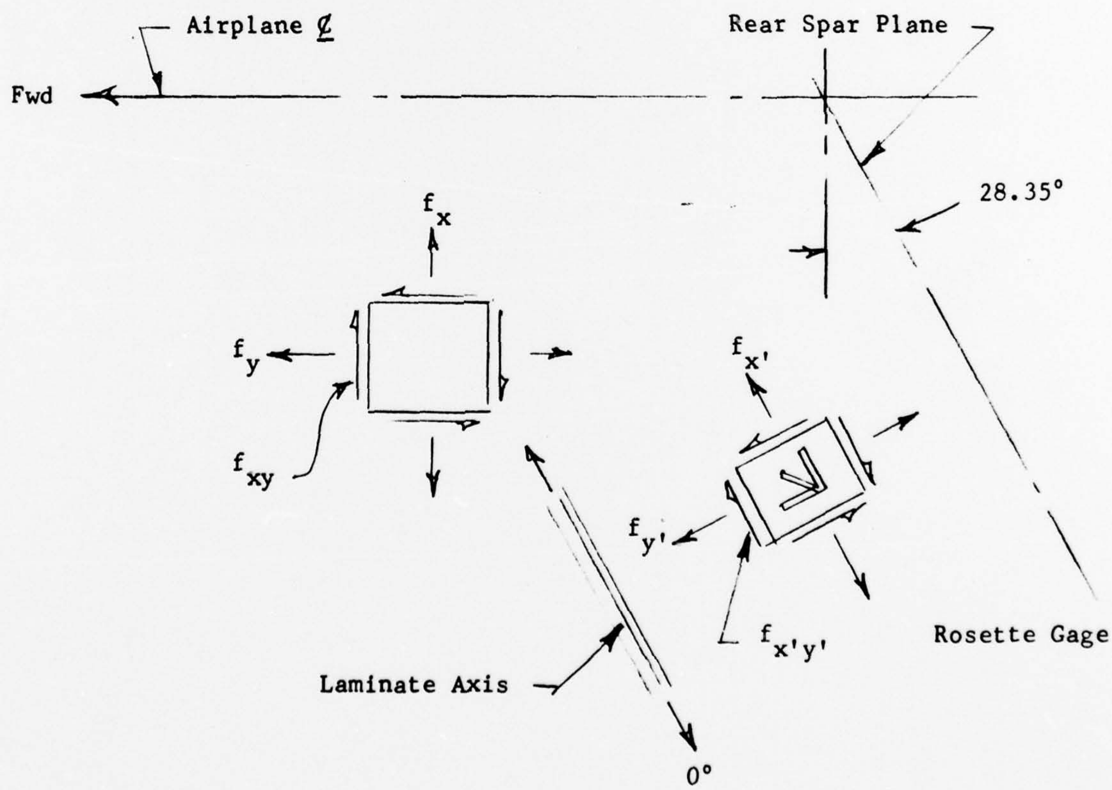

Figure C-25 NASTRAN Stress Axis Rotation

TABLE C-4

COMPARISON OF RECORDED AND PREDICTED STRAINS AT 150% D.L.L.

Max. vertical landing cond.

Wing Upper Cover Gages

Gage No.	Gage Type	$\varepsilon_{x'}^{*}$	$\varepsilon_{x'y'}^{*}$	$\varepsilon_{y'}^{*}$
1_o	Rosette	-3423(-3608)	288(451)	1925(2340)
1_i	↑	-2791(-3136)	331(348)	1715(2122)
2_o	│	-3607(-4279)	-150(-258)	2622(2568)
3_o	│	-2105(-2739)	-286(333)	891(1899)
4_o	│	-3180(-3653)	-112(-427)	Gage out
5_o	│	-1761(-1851)	Gage out	216(529)
5_i	│	-1149(-1417)	- 10(280)	335(608)
6_o	│	-2817(-3746)	208(211)	1412(1721)
7_o	│	-3227(-3908)	- 39(-207)	1797(2091)
8_o	│	-2054(-2748)	111(85)	1309(1699)
9_o	│	-2768(-3169)	-231(-291)	1085(1444)
10_o	│	-2645(-3263)	-530(-315)	1346(1688)
11_o	↓	-2650(-2500)	-590(-333)	698(907)
12_o	Rosette	-1559(- 933)	-975(-930)	782(135)

Wing Lower Cover Gages

Gage No.	Gage Type	$\varepsilon_{x'}^{*}$	$\varepsilon_{x'y'}^{*}$	$\varepsilon_{y'}^{*}$
1_o	Rosette	3003(3413)	-270(-637)	Gage Out
1_i	↑	2724(3094)	-252(- 36)	-1744(-1712)
2_o	│	3155(4025)	- 41(103)	-2387(-2754)
3_o	│	2243(2396)	149(-525)	-1408(-2060)
4_o	│	2545(2952)	260(1421)	-1209(-1867)
5_o	│	1527(1727)	174(-255)	- 68(- 310)
5_i	│	1373(1257)	-300(-353)	- 261(- 499)
6_o	│	2695(3526)	- 84(-119)	-1287(-1469)
7_o	│	Gage out	115(75)	-2032(-1954)
8_o	│	1288(1838)	-337(-416)	-1429(-1409)
9_o	│	2316(2872)	91(239)	- 898(-1296)
10_o	│	2476(3029)	387(323)	-1271(-1612)
11_o	↓	2042(2329)	Gage out	Gage out
12_o	Rosette	Gage out	984(1151)	-1395(- 301)

*NASTRAN Predicted Values in parenthesis

o - outer skin
i - inner skin

TABLE C-4 (Concluded)

COMPARISON OF RECORDED AND PREDICTED STRAINS AT 150% D.L.L.

Max. vertical landing cond.

Wing Spar Gages

Gage No.	Gage Type	$\varepsilon^{*}_{-45°}$ in/in.	$\varepsilon^{*}_{90°}$ in/in.	$\varepsilon^{*}_{+45°}$ in/in.
13 aft int. spar	Rosette	Gage out		
14 aft int. spar	↕	-1235(-1321)	-579(0)	1020(1321)
15 fwd. spar	↕	392(200)	- 39(0)	-153(-200)
16 rear spar	↕	- 143(- 139)	128(0)	-112(139)
17 rear spar	Rosette	- 453(- 416)	238(0)	- 52(416)

Wing Rear Spar Cap Gages

Gage No.	Gage Type	$\varepsilon_{x'}^{*}$ in/in.
18 U_o▲	Axial	-1685(-2446)
18 L_o■	↕	2284(2488)
19 U_o	↕	-1923(-2820)
19 L_o	↕	2254(2821)
20 U_o	↕	-2926(-3099)
20 L_o	Axial	3041(3148)

*NASTRAN predicted values in parenthesis

▲ U_o denotes upper cap outer surface

■ L_o denotes lower cap outer surface

C-5-2 Comparison of Predicted and Measured Strains (Cont'd.)

The following sample calculations are shown to illustrate the rotation of NASTRAN stresses from the X-Y reference system to the X'-Y' reference system at upper cover rosette gage location 1_o:

$f_x = -31{,}312\#/in^2$

$f_y = -1140\#/in^2$ Ref. NASTRAN Stresses

$f_{xy} = -7747\#/in^2$ $\theta = 28.35°$ (Ref. Figure C-25)

$$f^*_{x'} = \frac{f_x + f_y}{2} + \left[\frac{f_x - f_y}{2}\right] \cos 2\theta + f_{xy} \sin 2\theta$$

$$= \frac{-31{,}312-1140}{2} + \left[\frac{-31{,}312+1140}{2}\right] \cos 56.7° - 7747 \sin 56.7°$$

$$= \underline{-30{,}984\ \#/in.^2}$$

$$f^*_{y'} = \frac{f_x + f_y}{2} - \left[\frac{f_x - f_y}{2}\right] \cos 2\theta - f_{xy} \sin 2\theta$$

$$= \frac{-31{,}312-1140}{2} - \left[\frac{-31{,}312 + 1140}{2}\right] \cos 56.7° + 7747 \sin 56.7°$$

$$= \underline{-1468\#/in.^2}$$

$$f^*_{x'y'} = -\left[\frac{f_x - f_y}{2}\right] \sin 2\theta + f_{xy} \cos 2\theta$$

$$= \left[\frac{-31{,}312 + 1140}{2}\right] \sin 56.7° - 7747 \cos 56.7°$$

$$= \underline{8356\#/in.^2}$$

* Ref. MIL-HDBK-17A Pg. 3-17 (Mohr's Circle Rotation)

C-5-2 Comparison of Predicted and Measured Strains (Cont'd.)

The corresponding strains in the X'-Y' reference system are determined in the following manner:

Material Properties:

$E_{x'} = 8.3 \times 10^6$ #/in.^{2} $E_{y'} = 3.8 \times 10^6$ #/in.^{2}

$G_{x'y'} = 3.85 \times 10^6$ #/in.^{2}

$\mu_{x'y'} = .73$ $\mu_{y'x'} = .33$

$$\dagger f_{x'} = \frac{E_{x'}}{1 - \mu_{x'y'} \mu_{y'x'}} \left[\mathcal{E}_{x'} + \mu_{y'x'} \mathcal{E}_{y'} \right]$$

$$-30{,}984 = \frac{8.3 \times 10^6}{1 - .73\,(.33)} \left[\mathcal{E}_{x'} + .33\, \mathcal{E}_{y'} \right]$$

$$\underline{\mathcal{E}_{x'} + .33\ \mathcal{E}_{y'} = -2835 \times 10^{-6}}$$

$$\dagger f_{y'} = \frac{E_{y'}}{1 - \mu_{x'y'} \mu_{y'x'}} \left[\mu_{x'y'} \mathcal{E}_{x'} + \mathcal{E}_{y'} \right]$$

$$-1468 = \frac{3.8 \times 10^6}{1 - .73(.33)} \left[.73\, \mathcal{E}_{x'} + \mathcal{E}_{y'} \right]$$

$$\underline{\mathcal{E}_{x'} + 1.37\, \mathcal{E}_{y'} = -401.8 \times 10^{-6}}$$

Solving simultaneously -

$\mathcal{E}_{x'} = -3608\, \mu$ in./in.

$\mathcal{E}_{y'} = 2340\, \mu$ in./in.

† Ref. Advanced Composite Design Guide, Vol. IV, Page 4.2.7

C-5-2 Comparison of Predicted and Measured Strains (Cont'd.)

$$^{\dagger}f_{x'y'} = G_{x'y'} \left[2\,\varepsilon_{x'y'} - (\varepsilon_{x'} + \varepsilon_{y'}) \right]$$

$$8356 = 3.85 \times 10^{6} \left[2\,\varepsilon_{x'y'} - (-3608 + 2340)10^{-6} \right]$$

$$\varepsilon_{x'y'} = \underline{451\,\mu} \text{ in./in.}$$

† Ref. Advanced Composite Design Guide, Vol. IV, Page 4.2.7

Strain gages at location 12 (Reference Figure C-18) have their "A" legs oriented parallel to the front spar which is swept forward 18.1° from an axis parallel to the rear spar. The laminate axial moduli, shear modulus and Poisson's Ratios for this strain angle were determined from transformation calculations described in AFML-TR-78-33 dated March 1978.

The comparison of measured and predicted strains presented in Table C-4 shows reasonable correlation in most areas of the test box structure. In general, the calculated strains are conservatively higher than the measured strains. In all cases the biaxial strain patterns of the orthotropic cover skin laminates are in the direction and proportion predicted by the NASTRAN analysis.

Factors which may contribute to differences in predicted and measured strains include the following:

- Bending stiffness of spar webs was not included in the NASTRAN model.
- Skin thickness in areas of tapering laminate thickness adjacent to the centerline rib and B.P. 33 rib may not be accurately represented.
- Difficulty in calculating the strain at the exact gage locations due to the fact that the NASTRAN model provides only an average strain in each cover skin element and the gradient between adjacent elements is rather steep in some cases.
- Possible variations in calculated and actual modulus values of the orthotropic cover skin laminates.
- Tolerance in the accuracy and repeatability of strain gage measurements.
- Small differences in test load application versus NASTRAN model load application.

C-5-2 Comparison of Predicted and Measured Strains (Cont'd.)

In summary it may be stated that the NASTRAN analysis provided a conservative representation of the internal stress distribution and accurately identified the pattern of strain distribution throughout the structure.

C-5-3 Comparison of Predicted and Measured Deflections

Table C-5 presents a comparison of predicted and measured deflections. The measured deflections include a correction based upon an approximate upbending rotation of 0.19° at the root of the forward spar as measured by deflection transducers 32 and 33. Bending rotation at the root of the rear spar was too erratic to be utilized. Excellent agreement is shown between all the measured and predicted deflections with the measured values slightly less than the predicted values.

WING TEST BOX VERTICAL DEFLECTIONS

Max. Vertical Landing Cond.

(Max operational loads - 150% D.L.L.)

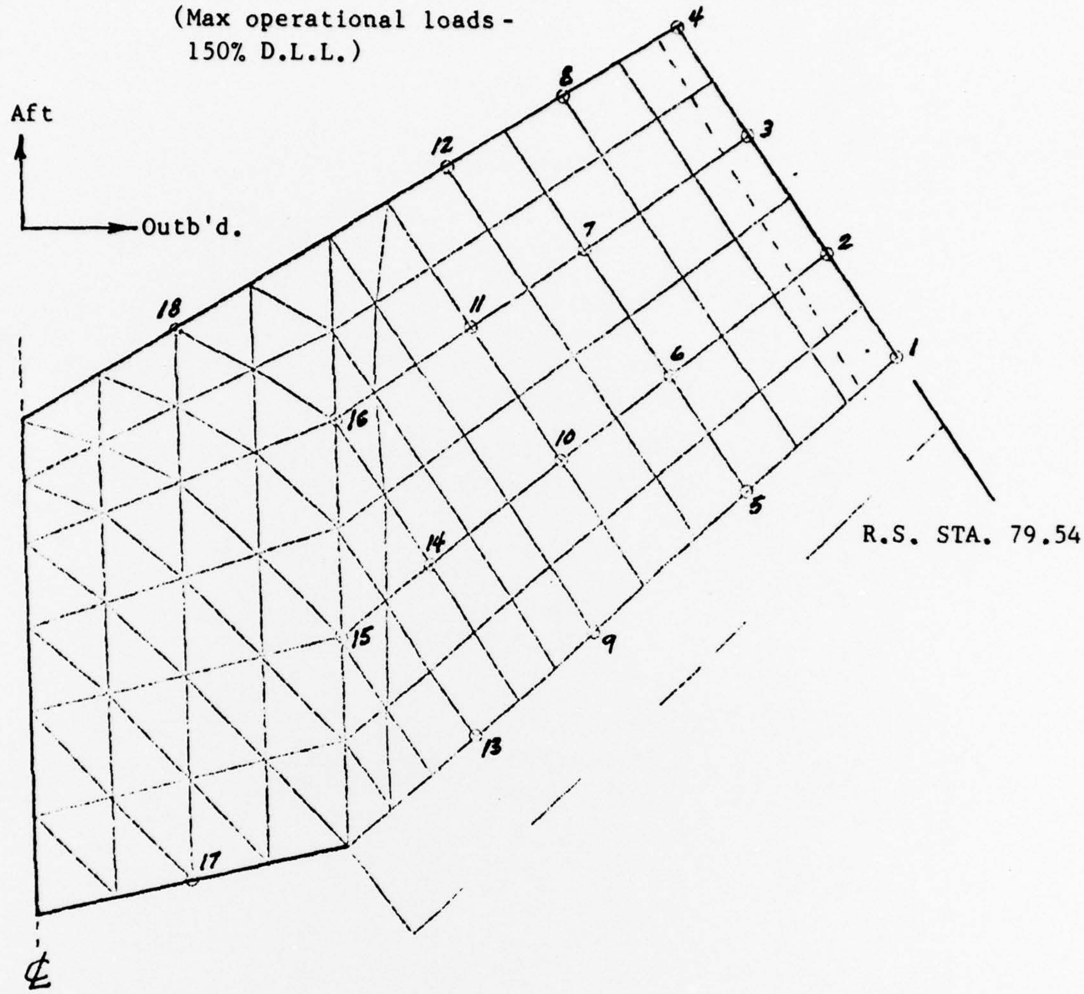

TABLE C-5

COMPARISON OF PREDICTED AND MEASURED DEFLECTIONS AT 150% D.L.L. (IN.)

Location	Predicted*	Meas.	Location	Predicted*	Meas.
1	2.7	2.64	10	1.16	1.15
2	2.65	2.49	11	1.05	.97
3	2.56	2.44	12	1.07	.98
4	2.42	2.25	13	.55	.53
5	1.79	1.78	14	.68	.65
6	1.71	1.70	15	.46	.54
7	1.58	1.54	16	.61	.43
8	1.69	1.47	17	.07	.05
9	.99	1.03	18	.17	.14

*Based on NASTRAN

C-6 FATIGUE LOAD TEST

C-6-1 Fatigue Load Spectrum

A landing load fatigue test spectrum was determined for the composite wing box test section based upon the V/STOL landing criteria specified for the XFV-12A prototype aircraft. This criteria is defined in "NR-356 V/STOL Technology Design Criteria Report" (NR72H-330-2) and conforms to the requirements of MIL-A-8866. Figure C-26 presents the V/STOL sink speed probability curve for the XFV-12A based upon a maximum vertical sink speed of 15 feet per second.

Table C-6 presents the fatigue test load distribution to be applied for each 1000 flight hours based on the probability distribution of Figure C-26.

TABLE C-6

V/STOL LANDING LOAD SPECTRUM
FOR EACH 1000 FLIGHT HOURS

Sink Speed V_v (Ft./Sec.)	Probability	$\frac{\Sigma N}{1000}$	$\frac{N}{1000}$	V_v^2	% Ult $\frac{V_v^2 \times 100}{225}$
15	.001	1	1	225	100.00
14	.003	3	2	196	87.11
13	.012	12	9	169	75.11
12	.032	32	20	144	64.00
11	.085	85	53	121	53.78
10	.140	140	55	100	44.44
9	.250	250	110	81	36.00
8	.420	420	170	64	28.44
7	.600	600	180	49	21.78
6	.740	740	140	36	16.00
5	.870	870	130	25	11.11
4	.930	930	60	16	7.11
3	.980	970	40	9	4.00
2	1.000	1000	30	4	1.78

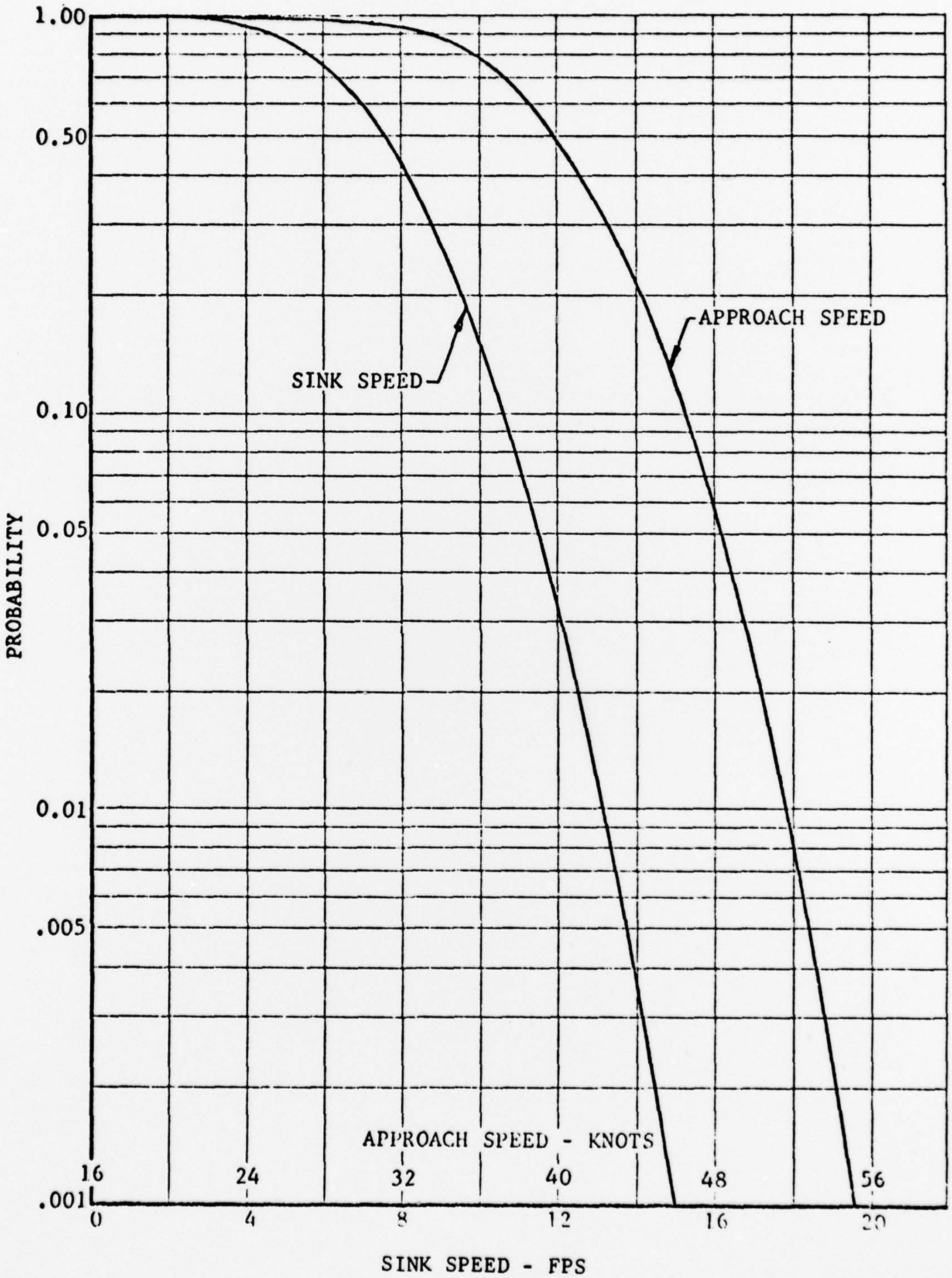

Figure C-26 Probability of Exceeding Sink Speed and Approach Speed for XFV-12A V/STOL Landings

C-6-1 Fatigue Load Spectrum (Cont'd.)

This spectrum was applied twelve times to the composite wing box test section to represent two lifetimes of service based upon 6000 flight hours per lifetime. The loading spectrum was truncated at 21.78% of maximum load and the sequence of loading progressed from 21.78% to 100% of maximum load in each of the twelve blocks of loading.

C-6-2 Fatigue Load Test Results

Two lifetimes of the fatigue load spectrum of Paragraph C-6-1 were completed on 20 September 1978. There was no evidence of damage or permanent deformation in the composite wing box test section as a result of this series of test loadings. Strain gage measurements taken at the 100% fatigue test load level were essentially identical to those recorded during the static test loadings at the max. operational load level (150% D.L.L.).